Electrochemical and Metallurgical Industry

NEW YORK, OCTOBER, 1906.

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The Wasteful Combustion of Coal.

Coal mining is the greatest mining industry of this country. The vast sedimentary rocks of the carboniferous age throughout North America carry from coast to coast large deposits of coal varying from graphite and anthracite to the brown lignites of Texas and Dakota. The aggregate tonnage is almost four hundred million tons per annum (three hundred and ninety millions in 1905), giving direct employment to an army of grimy miners, and indirectly to a still larger army in the industrial world. Coal is potential energy—the "stored-up sunlight," as Stephenson said, of past ages. The means for converting this treasure into actual and commercial energy should be the most efficient and economical that chemical knowledge and engineering skill can devise. Yet, on the contrary, we find the means usually employed most wasteful and inefficient. Let us consider the ordinary burning of soft coal under a boiler for raising steam. There are two operations—the coking or distillation of the volatile hydrocarbons and their combustion, and next the combustion of the coke (or fixed carbon in noncoking coal). The air from under the grate passes through the coke, and is, in part, turned into producer gas. It thus diminishes the activity of the oxidizing power of the atmosphere above the incandescent bed. These gases, not well mixed, pass on the water-cooled metallic surface of the boiler, and combustion is stopped. For complete combustion, a high temperature for some interval is required, while the cold surface of the metal chills the gases to such a point that the "reaction-velocity" of combustion is reduced to nil. This is made much worse by the intermittent character of the operation. We thus see that we are performing two distinct metallurgical operations in a cramped space under bad conditions, and are thus violating two canons of metallurgical science.

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It is not hard to design a smoke-consumer. A reverberatory copper furnace burns the "smokiest" of soft coal and produces little or no smoke. The reason is that the two operations of distillation and combustion are done separately, under right conditions, and in a nearly continuous process. To make this, for purposes of steam raising, commercial as well as practical, is a harder matter. However, with proper thermal insulation and proper design this is possible, although great capital outlay militates against it. A better way would be larger central installations of by-product coke-ovens, selling gas at a cheap rate, and using the coke for producer-gas engine operations, as well as for metallurgical purposes and domestic uses. Or the "weak" by-product gas could be utilized for a large gas-engine electric installation and electric power sold. Here we have two operations separate, and both continuous, which is the proper set of

circumstances for good metallurgical work. But, here again the bugbear of large capital outlay flares itself up in the face of those desiring an approximation to ideal and perfect utilization of the gifts of bountiful Dame Nature.

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The work of the U. S. Geological Survey at the coal-testing plant at St. Louis is, however, welding the ideal with the real in the combustion of coal and making widespread the true theory of combustion of soft coal. This work is of so important a nature that Congress should continue it on a much amplified scale, and make it as fine an institution for research as the Department of Agriculture is for the "new farming" that is manifesting itself in increased yield per acre in the United States. The conservation of Nature's fixed resources, and the utilization of them for the benefit of posterity, is the highest ideal of statesmanship. And in this the world owes a debt of gratitude to the grand work of the German universities. The application of broad philosophical principles to every-day life is the keynote of the twentieth century.

The Eight-Hour Day in Smelting Plants.

Acute observers for ages have been predicting ever-increasing troubles in handling labor in this country, and, in fact, in all the world. The division of the unearned increment, or that portion of the wealth which comes to the complex organism society, is manifestly in many cases unfair, and the law of the survival of the fittest is rigorous and severe on the unfit. However, society blunders along, and a distinct amelioration of the laboring classes has resulted. The shortening of the hours of labor gives more time to relaxation and rest to the workman. In the metallurgical industry this same effect is marked. Wherever large machines are installed, the keenest nerves and "muscular co-ordination" are a prime requisite. Long hours will weary the workman so much that the necessary physical skill diminishes. And the end of the matter is that the efficiency of the workman is reduced and the efficiency of the machine is also lowered. Hence where great capital outlay for labor-saving machinery has been made, the pay and the hours of the workman are most satisfactory to him. All is summed up in the words "maximum efficiency." This is especially true of rolling steel blooms into finished form. And the expert steel roller receives pay commensurate with the high-priced professional ball player, whom, in fact, he resembles in quality of nerve and muscle.

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In much work, however, the duties of the workman are for a great part of shift only those of attendance, and the workman can enjoy comparative ease with pipe in mouth, knowing by sound of machinery that "things are going all right," using little physical labor except where repairs are needed. This is seen to a more or less extent in the handling of mechanical reverberatory furnaces, concentration mills, and shaft furnaces in cases where charge descends easily and furnace works well due to excellent metallurgical conditions. Here a twelve-hour day is no great hardship to the furnaceman, and a short shift would be had not only because hourly pay must be increased, but because the long shift gives the furnaceman a chance to gather a much better insight into

the working of the furnace. Shaft furnaces, however, when hand charged, are run best on eight-hour shifts for hand charges and twelve-hour shifts for the furnaceman.

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The question of operating plant at maximum efficiency demands men whose minds and bodies are run at maximum efficiency. The human body is something like a storage battery. Heavy discharge causes "sulfation," as excessive labor deteriorates the physical tone. Too rapid charging is inefficient, as is too much food for a man. A battery standing idle loses its ampere-hour capacity, as a man's muscles out of work get soft and flabby. In a general way the analogy is complete. Both are tender and complex electrochemical machines, and both must be cared for intelligently or they get "sick." In conclusion of this most important subject, we might state that, as a usual thing, twelve hours a day is too long a period for the human being to breathe and work in hot and bad air at trying and difficult operations. And the eight-hour day in the long run, under modern conditions of high-priced machinery and high-priced labor, will be found for the advantage of both employed and employer. *

Education and Civilization.

At the present time when the universities begin their new terms, it is suggestive to think what the effect might be if all teaching and schooling should stop for fifty years. Every year about one-fiftieth of the human race dies, and about one-fortieth is born. Those dying take away with them all that they have learned in their lives, and those being born bring with them only the capacity to learn and a few animal instincts. The whole work then of educating the human race must be partly done over every fifty years. If, as suggested in the first sentence, we should miss one round, we would relapse many centuries, perhaps hundreds of them, toward the mere animalism from which our race originated. The preservation of our civilization itself requires, therefore, that education of the youth be maintained; it is the price we must pay for the continuance of our civilization; and it is evident that the preservation of our *progress* in civilization depends upon *progressive* improvement in the manner and substance of the instruction of the coming men.

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Another consideration then presents itself, viz.: how much time and attention should be given to education or schooling, how far it should go, how high it should reach. This is the question which the wise and the foolish of many countries, races and centuries have been trying to solve, and no one has successfully solved it or ever will. It is one of those questions which cannot be solved arbitrarily by any one's logical conclusions; it is a question which solves itself. Over-education, if it is ever reached in any one case, will correct itself by resulting in inability, through lack of means, of over-educating the succeeding generation. For if the immediate result of over-education is to make men vain, conceited and disinclined to hard work, mental or physical, it puts men out of touch and sympathy with their surroundings, out of harmony with the true principles of successful life, and its ultimate result will be inability to secure the means of over-educating the succeeding generation. Over-education would thus cause a re-

action, by which, for a time, the children would atone for the over-education of their ancestors by a period of salutary return to hard work and normal education. There can never be any fear of over-education producing any permanently baneful results.

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There certainly is not at present in America an over-supply of university-trained men in business, professional or political life. On the contrary the demand at present is for more of them. The boy whose schooling stops at the grammar school, enters life with a seventeenth century education. The boy who graduates from the High School, gets a nineteenth century education. The university student gets a twentieth century education, and should be abreast of the best thought of his time. This constitutes the difference which education makes in the equipment of a man for his life work, and shows what advantage the university graduate possesses, in theory at least. To be placed abreast of the latest developments in science and industry, to start in the forefront of the world's advancing throngs, to stand on the shoulders of former workers, and to start with a possession of the best that they have to teach, is the privilege of the university student— which some foolishly ignore, many desire, and but a favored few enjoy.

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Surely we do not want to imply that it is only the university graduate who is able to impress his individuality on contemporary life and to make history. The facts show too clearly that this is not so. In his admirable lecture before the Cornell students this Spring—at the time of the Ithaca meeting of the American Electrochemical Society—Mr. Edward G. Acheson, recognized by everybody as one of the foremost electrochemists of the world, tooks pains to emphasize that he is a self-made man and not a university graduate. Other captains of industry have proudly expressed themselves similarly. But a captain of industry is an exception. A genius will make his mark on the world under any conditions. Yet not everybody, fortunately, is a genius. A system of education has not to consider how to train the genius, but rather how to do the most good for progress on the whole, and considered in this light, there is no flaw in the above argument in favor of university education. Life, if it is worth while, is fighting. Goethe said, "Denn ich bin ein Mensch gewesen und das heisst eim Kämpfer sein." And in the fight which every man has to make in his life, his personal qualities are ultimately of decisive importance. But university education gives to a boy the best available weapons to make this fight.

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There exists, unfortunately, in commercial work, say in a metallurgical plant, often a disagreeable feeling between the university graduates and those who are not, when they should stand together in harmony. Some university men are too liable to look down on those who were less fortunate. The practical self-made man, if he has honestly earned his position, has earned it through hard and conscientious labor. By tireless observation he has acquired a faculty of feeling or perceiving by intuition whether the process works correctly or not. Such knowledge as he has he has acquired by himself. It is stored in him, and it will die with him. He could not have learned it from books or from teachers. This fact makes him

liable to underestimate or to wholly misunderstand the value of a scientific education. This is his mistake. But in many cases if we see what has been accomplished simply by consistent hard work with rule of thumb and try and miss methods we cannot but admire the man who did the work. Yet it remains a self-evident truth that we must get away from the rule of thumb, and must use instead exact scientific principles. The times have marvelously changed, and while we must admire the "practical man" of the past, the future belongs to the man whose work is based upon scientific principles. The practical furnace man in a metallurgical works of the past saw with his eyes whether the metal was at the right temperature. He did his work faithfully and successfully, but when he left the plant his knowledge went away with him. Now, in the period of pyrometers, a works is enabled to get a permanent record of the right succession of temperatures during a process. It is thus possible to repeat a successful process from the written record after success has once been established, and the plant is independent of the individual man. This illustrates clearly the industrial progress which has been made, and which is wholly the result of scientific progress, but the advance of pyrometry is only a single example of the tendency of the times—that is, advance of science for the sake of civilization and humanity.

The Effect of Colloids on Metal Deposition.

The beneficial effect which the addition of a very small quantity of a colloid to the electrolyte may have on the smoothness and density of the metal deposit is now well known. Mr. A. G. Betts was the first to employ this means on a large scale in his lead refining process. He found that the lead "trees" produced under ordinary conditions could be avoided, and a dense, coherent and solid lead deposit could be obtained by the addition of very small quantities of gelatine or glue to his electrolyte. Others have later applied the same means successfully for analogous purposes with other metals. But the rationale of the beneficial effect of the addition of a colloid has been a subject of much discussion and controversy. A new explanation has recently been offered, and has been made the basis of a patent by an engineer of the Siemens & Halske Co., Mr. J. A. Nussbaum, as mentioned in this issue under Analysis of Current Electrochemical Patents. His explanation is essentially that the metallic ions, when they give off their charges at the cathode, are not immediately deposited in metallic form, but exist for some time in a more or less unstable intermediate state. In this unstable form they are floating around in proximity to the cathode, and will pass over into the metallic state preferably at such places where metallic particles already exist (just as undercooled water will at once crystallize into ice around the smallest ice crystal dropped into the water). The effect of the addition of a colloid consists, according to Nussbaum, in the formation of a colloidal diaphragm near the cathode, which prevents the metal particles from floating freely around in their unstable intermediate form. This explanation seems, so far, purely hypothetical, but it has the advantage that it can be tested. If it is true, then only such colloids can be beneficial which travel with the current, since those colloids traveling in the other direction cannot form a protective diaphragm at the cathode.

Jubilee of the Coal-Tar Industry.

The jubilee of the coal-tar industries will be celebrated on Oct. 6 by a dinner, to be given at Delmonico's, New York, to Sir William Perkin, who invented the dye-stuff "mauve" fifty years ago.

A reception to Sir William will be held on Tuesday evening, Oct. 9, in the hall of the Chemists' Club, New York City.

The American committee which has arranged the Perkin celebration has extended a cordial invitation to the members of the American Electrochemical Society (which is to hold its meeting in New York City on Oct. 8 and 9) to attend both functions.

New York Meeting of the American Electro-chemical Society.

The Autumn meeting of the American Electrochemical Society will be held in New York City on October 8 and 9. This is in consequence of a decision of the Board of Directors to try and hold one meeting each year, in Spring, in some place to be selected from year to year, and a second and secondary meeting in Autumn regularly in New York City. The meeting to be held will, therefore, be somewhat in the form of an experiment to see how the plan works out. The idea is that many members of the society have to make professional trips to New York City in the Autumn, and could arrange to combine them with attendance at the meeting.

In the present case, the dates have been so selected as to enable those who attend the Perkin Memorial Celebration of the Foundation of the Coal Tar Industry, which will take place October 6, to also attend the meeting of the society.

The members of the society are invited to join the committee of the Perkin Memorial Celebration in a banquet, to be given to Sir William Perkin at Delmonico's on the evening of Saturday, October 6, at 8 P. M. The cost is $5.00 per plate.

On Monday, October 8 at 9 A. M., a meeting of the Board of Directors will be held at Columbia University, while the first session for the reading and discussion of papers will begin at 10 o'clock. There will also be an experimental lecture at this session. On the same day, at 2.30 P. M., Dr. Charles Baskerville will deliver an experimental lecture at the Chemical Laboratory of the College of the City of New York, on "The Use of Ultra-violet Light in the Laboratory and in Practice."

Tickets will be provided by the local committee for visiting numerous points of interest on the same afternoon, including the largest power houses, the Electrical Testing Laboratories, the Pennsylvania Railroad tunnel under the Hudson River.

On Monday evening, at 8 o'clock, a beefsteak supper, the cost of which will be about $3.50 per plate, will be held at Reisenweber's, Fifty-eighth Street and Eighth Avenue, or in the Liederkranz Hall. Further announcements will be made in the session on Monday morning.

On Tuesday morning at 9.30 a second session will be held for the reading and discussion of papers, and an experimental lecture. In the afternoon the members of the society, and guests, will be taken to the works of the American Smelting & Refining Co., near Maurer Station, N. J. Another party will visit the laboratories of Mr. Thomas A. Edison, in Orange, and possibly the Weston Instrument Co's plant.

On Tuesday evening the members are invited to attend the reception given to Sir William Perkin at the Chemists' Club.

The Boards of Directors of the Chemists' Club and of the German Liederkranz Society have courteously placed their club houses at the disposal of the visiting members of the Society during the meeting.

Since it is intended to hold the Autumn meeting regularly in New York City, the local New York committee, which has been appointed, is expected to make all necessary arrangements, but not to raise money for entertainment, all cost of entertainment being borne by the members attending. Hotel headquarters will be at the Prince George Hotel, East Twenty-eighth Street, New York.

Dr. A. H. Elliot, 4 Irving Place, is chairman of the general local committee. Mr. H. B. Coho is chairman of the entertainment committee.

The following is a list of the papers which have so far been promised:

Charles Baskerville, The Use of Ultra-violet Light.

C. F. Burgess, title not yet received.

Henry S. Carhart, Formula for the e. m. f. of a Helmholtz Concentration Cell.

G. H. Cole and H. T. Barnes, An Aluminium and Magnesium Cell.

Carl Hering, Visible Migration of Particles Between Electrodes.

H. E. Patten, Some Factors Affecting the Distribution Law.

Henry Noel Potter, title not yet received.

Francis R. Pyne, Melting Points of Some Cryolite-Alumina Mixtures.

E. F. Roeber, Use of Pyrometers, with Exhibitions.

P. B. Sadtler and W. H. Walker, Double Decomposition of Zinc Sulphate and Sodium Chloride.

S. S. Sadtler, Some Small Laboratory Appliances for Electric Fusion and Other Work.

J. W. Turrentine, Copper Cathodes in Nitric Acid.

F. F. Schuetz, A Thermo-Electric Pyrometer for General Industrial Applications.

F. B. Crocker, The Decker Primary Battery.

The Iron and Steel Market.

The rush to buy pig iron for all deliveries which characterized August subsided before the middle of September. The scarcity of prompt iron has continued, and still higher prices have been paid for small lots. Barring very unfavorable weather conditions and interference with the movement of raw materials, the market for prompt iron will have to yield to a largely increased supply, and prices for prompt and future reach a more harmonious relation.

The market in finished steel products has been uniformly strong. Buying and specifying has been hardly as heavy in September as it was in August, but total bookings for the month have been beyond output, and there is still less business left to be done in the late fall and winter.

It is difficult to particularize, where demand is so uniformly good from all classes of consumers, but it may be remarked that the railroads have shown increased activity in the buying of steel cars and the placing of blanket contracts for bridges for 1907. Their interest in rails has correspondingly diminished, sales for next year being relatively light, while the Western roads are exerting great pressure on the rail mills to have deliveries on 1906 contracts rushed to permit of closing up of outside work before the worst weather sets in.

It is as thoroughly established as can be with anything so fickle as the American iron trade, that the present very prosperous condition will be maintained at least until some time in the second quarter of 1907. Beyond that time the course of the market will be determined by the relation worked out between physical results this winter and the personal equation.

Pig iron production, and consequently the production of crude steel and finished products, will be much larger than in the quarter just closed; how much larger cannot be forecasted, nor can it be told to what extent this increase has been anticipated by the buyers who have been so actively in the market. On the relation between this increase, whatever it may be, and the amount of increase which buyers anticipated, will probably

depend the course of the market after the first quarter of next year.

PIG IRON.

Early in September, Bessemer and basic pig iron advanced to $18.75 and $18.50 f. o. b. valley furnace, respectively, at which prices they have since been firmly held, with light sales. Occasional prompt lots of Bessemer have been sold by middlemen at $19.00, valley, equal to $19.85 delivered Pittsburg or Cleveland. The large steel interests have done practically nothing, having found they would have to adjust their steel output to their own supply of steel-making pig. The floating supply of both grades is fairly well taken up to the middle of next year.

Buying of foundry iron has also diminished, on account of the higher prices and the fact that the majority of large consumers are covered fairly well through the first quarter or first half of next year. Buying of prompt foundry iron has been active. In August this buying was by consumers who were not covered; in September many of the buyers had contracts, but were not getting the desired deliveries. Prices have advanced sharply, but the market has been too irregular to quote definitely. For anything like prompt delivery the valley furnaces have been obtaining $20 at furnace, or $20.85 delivered Pittsburg. Eastern furnaces have obtained $21.00 to $22.00 delivered to the Philadelphia district.

The Southern market is a shade easier, in the sense that the $15.00, Birmingham, price can be done in some instances on deliveries beginning late this year. For prompt shipment $15.50 to $16.00 is still obtained.

Production is increasing rapidly in all districts. The United States Steel Corporation since the middle of September has had about 95 per cent of its furnace capacity in blast, or above the normal, since the necessities of relining take an average of about 10 per cent. Many outside furnaces are coming in after relining, the humidity has decreased and unfavorable winter weather is not due yet. In Alabama there is a car shortage, which has interfered with even the short hauls for coke, limestone and ore, and is claimed to have somewhat interfered with actual pig iron production, although shipments are made fairly well.

BILLETS AND SHEET BARS.

The supply of soft steel has materially improved, but as producers were so far behind in deliveries on their regular contracts but little additional material has been thrown on the open market. Soft steel billets can still be quoted at $28.00 to $29.00, Pittsburg, for Bessemer, and $29.00 to $30.00 for open-hearth. For delivery next year considerably lower prices have been quoted in some instances, and it is probable that if any large tonnage is sold it will be at a couple of dollars or so below the prices just named.

Sheet bars are nominally $30.00 to $31.00, Pittsburg, for odd lots, but the bulk of the tonnage moving is at $29.00 or less. Two sales of round lots for first quarter delivery have been made at less than a basis of $29.00, Pittsburg. On the quarterly contracts of the leading interest a price of $28.00 was made for the second quarter, and of $29.00 for the third quarter. A considerable portion of the steel specified under these contracts for earlier delivery will go out in the current quarter.

Attention should be called to an anomaly which has existed for some time and has become more pronounced in the past month, and that is the relative scarcity of steel which answers to any description other than that of ordinary soft steel billets. Billets under the standard 4 x 4 size have long been very scarce, and in many cases have been bringing the merchant bar price of 1.50c., or $33.60 per gross ton, there being no extra on such sizes. It is a fact that a large tonnage of such billets has actually been rolled on merchant mills. There have been times when it was difficult for a manufacturer to obtain any extra at all for small billets over 4 x 4. The large mills are being pushed to the limit, and do not care to reduce out-

puts, when the ingots are available, to make small billets except for their own requirements.

Similar large premiums rule in steels of any special analysis whatever. Large orders for axle billets and forging billets have almost gone begging, when the buyer was willing to pay from $3.00 to $5.00 a ton more above the market for ordinary soft steel. In times of comparative depression, steel mills have been only too glad to make material of special quality at a slight advance. It is not that demand for special steels has increased, but that there is such pressure that any departure means a loss of output. Furthermore, the increases in steel making capacity in the past few years have been chiefly in the direction of making ordinary steel. The very large producers have enlarged their Bessemer and open-hearth departments in order to find enough steel for their own finishing mills, not for the purpose of putting crude steel on the market. The smaller interests which have built steel mills have done so to supply their own requirements, and while they usually have limited tonnage of crude steel for the market, they can readily sell the surplus as soft steel, and do not need to bother with special analyses.

FINISHED MATERIAL.

The great bulk of the finished steel production of the country to the end of the first quarter is disposed of, either by outright sales or by contracts upon which specifications are being placed freely.

Rails have been quiet the past month, but it is between seasons. The early buying filled up the Southern and Western mills for nearly all of next year, while the Eastern mills are sold up for from a fourth to a half of the prospective production. Light rails have been very active, the mills making light rails from new steel being sold up for from three to four months ahead, which is very far ahead for this trade. The rerolling mills have all the prompt business they can handle.

Large steel car orders are being placed, and the car plants will soon be filled until nearly the middle of next year. The lake shipyards are almost filled for next year, and specifications for plates and shapes are correspondingly good. Fabricated structures are being placed freely.

Three large steel bar producers—Cambria, Republic and Crucible—have now advanced their price on steel bars to a minimum of 1.60c., but the Steel Corporation and some other producers are opposed to any advance, and continue to sell at 1.50c., which will remain the market, although deliveries are getting farther behind. Tin plate has been very active, contracts being placed freely for first quarter, and in some cases also for second quarter. Sheets are firm, but hardly as active as in August, and the prospect of an advance has almost disappeared.

The following prices are f. o. b. Pittsburg, plus regular rail freight to destination, and are regular mill prices on carload and larger lots for forward delivery; in the case of sheets and tin plates a concession of 5 cents a hundred pounds is usually given to good buyers; in wire products a similar concession is given to the largest jobbers:

Beams and channels, 15 inches and under, $1.70 per 100 pounds; tees, $1.75; beams and channels over 15 inches, $1.80.

Plates, tank quality, ¼ inch and heavier, 100 inches wide or less, $1.60.

Sheets, 28 gauge, box annealed, one pass, cold rolled, $2.50; galvanized, 28 gauge, $3.55; blue annealed, No. 10 gauge, $1.75.

Plain wire, $1.70 per 100 pounds; wire nails, $1.85 per keg, both base.

Tin plates, 100-pound cokes, $3.75 per box.

OBITUARY.—We regret to report the death, at Duino, on Sept. 5, by his own hand, of Prof Ludwig Boltzmann, of the University of Vienna. He was one of the most brilliant contemporaneous theoretical physicists, and especially distinguished himself in the development of electromagnetic theory, the mechanical theory of gases and thermodynamics. The

World's Pig Iron Production.

Provisional or final statistics of pig iron production in the first half of 1906 have been returned from the United States, Great Britain, Germany, Belgium and Canada, from which fairly trustworthy deductions may be made for the entire calendar year, while other countries may be assumed to have changed their production but little from 1905, and the total prospective pig iron production of the world in 1906 may be approximated with a probable error of considerably less than a million tons, as in the table below, which shows the ascertained outputs in 1900 and 1905 as far as possible. The United States, Great Britain and Canada return their statistics in gross tons of 2,240 pounds; other countries use the metric tons. Not to do violence to the statistics of two of the three greatest iron producing nations, the metric tons are reduced to gross tons to permit of the figures being added.

World's Pig Iron Production.

Tons, 2,240 Pounds.

	1900.	1905.	1906. (Prospective)
United States.....	13,789,242	22,992,380	25,300,000
Germany	8,381,373	10,813,979	12,055,000
Great Britain......	8,959,691	9,592,737	9,890,000
France	2,669,966	3,028,376	3,028,376
Russia	2,889,789	2,931,257[1]	2,931,257
Austria-Hungary .	1,472,695	1,300,000[2]	1,400,000
Belgium	1,001,872	1,329,109	1,385,000
Sweden	518,263	518,967	518,967
Spain	289,315	377,046	377,046
Canada	86,090	468,003	570,000
Italy	15,619[3]	110,819	110,819
Japan	......	33,335[4]	33,335
Other countries....	100,000	200,000	200,200
Totals	40,173,915	53,695,189	57,800,000

[1] 1904. [2] Estimated. [3] 1901. [4] 1903.

British Iron and Steel Production.

The British Iron Trade Association has returned the production of pig iron and of open-hearth steel ingots and castings in the first half of this year, and we make the following comparisons, the figures all referring to gross tons of 2,240 pounds:

Pig Iron Production.

First half 1905.................... 4,621,600
Second half 1905................. 4,971,137
First half 1906................... 4,905,424

As the last six months of the year contain three days more than the first six months, by actual half years the production in the first half of this year would exceed that of the second half of last year, and thereby become the greatest production in any half year in the country's history. The fact is worth noting, since the British iron trade does not break records with American facility. As far back as 1868 as much iron was made in one year as is now made in a half year.

Open-Hearth Steel Production.

First half 1905.................... 1,980,095
Second half 1905................. 1,899,653
First half 1906................... 2,196,853

Of the production in the first half of this year, 1,638,667 tons were made by the acid process and 558,186 tons by the basic. The acid process gained only 10,969 tons over the first half of 1905, while the basic gained 205,789 tons.

Hydrochloric Acid and Caustic Potash.

The Roberts Chemical Co., of Niagara Falls, electrolyze potassium chloride. At the cathode caustic potash is produced and hydrogen is set free, while at the anode chlorine is set free. The quantities of hydrogen and chlorine are in equivalent proportions, so that they may be combined to form hydrochloric acid. This is done by the Roberts Chemical Co., the two products of which are, therefore, hydrochloric acid and caustic potash. In the September issue of *Things Chemical,* of the Charles E. Sholes Co., who are the sales agents of the Roberts Chemical Co., it is pointed out that on account of its method of production, this hydrochloric acid cannot contain the ordinary impurities of muriatic acid unless they were expressly and intentionally added. Its only impurity is a small amount of free chlorine, which gives it a pale yellow color. This acid is of special interest to manufacturers of fine chemical products, gas mantles, cereals and foodstuffs (where there must be no arsenic), high grade and fancy leathers, and in general, for all purposes where quality is of more importance than a slightly increased first cost. The electrolytic caustic potash is made in three forms: fused (solid) in drums of 100, 200 and 800 pounds; broken in drums of 100, 250, 500 and 1,000 pounds, and caustic potash solution in drums of 325, 650 and 1,350 pounds. The solid and broken grades analyze not less than 85 to 87 per cent KOH and 10 to 15 per cent carbonate and chloride of potassium. The solution contains 45 to 47 per cent KOH. Caustic potash is now very largely used in electroplating shops for removing grease from metallic surfaces before plating. In the laundry, a dilute solution of caustic potash is an excellent "builder," for the soap will remove all grease and produces excellent suds, without injury to the fabric. Soap makers use caustic potash especially for all the finest soaps, whereas caustic soda is used for the common grades.

British Steel Combine.

The British steel tube manufacturers have finally effected a combination, after years of effort, the importance of which is evident by the fact that the annual gross output of the firms concerned amounts to 300,000 tons, valued at over $29,000,000. There are some sixty firms in the tube trade in the United Kingdom, and with the exception of one Glasgow house they have, according to the London *Economist,* entered into a compact to cease from cutting prices of a prepared schedule. Discounts on all kinds of tubes, except those for boilers have been reduced by 2.5 per cent, and prices of all sections of tubes for export have been advanced by 5 per cent on the net, these prices to hold firm until officially altered, which may be before long and on the upward grade. Boiler tubes have been left off the schedule, because the independent Glasgow firm makes a specialty of these. Germany is not now a competitor in steel tubes, and it is anticipated by expert authorities that with this agreement an international arrangement for the regulation of the world's tube trade will sooner or later be evolved. Measures toward that object are to be at once undertaken. It is calculated that out of the total British product 70 per cent goes abroad. The British Iron Trade Association has ascertained that the total output of open-hearth steel in the United Kingdom in the first half of 1906 was 2,183,856 tons, which compares favorably with an output of 1,980,095 tons in the first half of 1905, and 1,670,129 tons in the first half of 1904. The increase in 1906 was shared by every manufacturing district.

OBITUARY.—Mr. Louis Schutte, president of the Schutte & Koerting Co., Philadelphia, Pa., died on Sept. 29, at the age of 65 years. Mr. Schutte was born in Germany and graduated from the School of Technology in Hanover in 1862. In his professional work he later became associated with Mr. Ernst Koerting. He came in 1870 to this country, and founded, together with Mr. Koerting, the Philadelphia firm which bears their names.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

PRODUCTION, HEATING AND DRYING OF AIR BLAST.

This is a subject intimately related to the running of iron blast furnaces, and incidentally related more or less to all classes of metallurgical operations. The principles involved are those of physics—mechanical and thermal—and when once thoroughly understood can be used for the most various classes of metallurgical problems.

PRODUCTION OF BLAST.

There are two different principles upon which air is compressed, represented by the fan and the piston machines. The first is constant in its operation. the second intermittent, the first draws in and expels a continuous current of air, the second draws in a given quantity of air, compresses it and expels it. Measuring the work done by the difference in static conditions of the compressed and of the uncompressed air, the work actually done is a fixed and calculable quantity, independent of what type of machine performs it. During the compression, heat is generated, and the mechanical work done includes the mechanical equivalent of the heat thus generated. This is allowed for in the well-known formula for adiabatic compression:

$$Work = \frac{y}{y-1} V_0 p_0 \left[\left(\frac{p_1}{p_0} \right)^{\frac{y-1}{y}} - 1 \right]$$

in which

y = the ratio of the specific heat of air at constant pressure to that at constant volume = 1.408.
V_0 = the volume of the uncompressed air.
p_0 = the tension of the uncompressed air.
p_1 = the tension of the compressed air.

If we use the value of $y = 1.408$, the coefficient $\frac{y}{y-1}$ becomes 3.45, and $\frac{y-1}{y}$ = 0.29. If we then use the other dimensions in feet and pounds, the resulting work done will be in foot-pounds; if we use meters and kilograms, in kilogram-meters. The element of time does not enter into this equation, the work actually done is the same for compressing a given amount of air, and is independent of the time. If I lift a kilogram 1 meter high, the same amount of work is done whether I lift it in 1 minute or in 1 second; the *rate of doing work* would be, however, sixty times as great in the last instance as in the first, but the actual amount of work accomplished is the same in each case. If, therefore, we use in the formula the volume of air entering the compressor per minute, the result will give the work done per minute; if we use the volume per second we get the work done per second. If we wish to transpose the work done into horse-power, we bear in mind that a horse-power is understood in English units as 33,000 foot-pounds of work done per minute, and in the metric system as 75 kilogrammeters of work done per second.

In applying the formula we may further notice that $\frac{p_1}{p_0}$ expresses the ratio of compression; that is, by how many times the tension of the original air is increased. If air at one atmosphere tension (such as the air we usually have to breathe) is compressed to two atmospheres tension, the ratio of compression is 2; if air entered a machine at two atmospheres tension and was therein compressed to four atmospheres tension, the ratio of compression would be likewise 2, and the work done (for a given quantity of air) the same as before.

The effective pressure, as shown on a gauge, is the *difference* between these two tensions; it is not p_1. It is highly important that this point be held clearly in mind. The tension of the uncompressed air is its barometric pressure. as measured against a vacuum; the tension of the compressed air is likewise its pressure as measured against a vacuum; the effective pressure of the compressed air is the difference between these two tensions; the tension of the compressed air is, therefore (by transposition), equal to the barometric pressure of the uncompressed air plus the effective pressure of the compressed air, i. e., plus the gauge pressure. Never use the effective pressure of the compressed air as p_1, but always add to it the barometric pressure of the uncompressed air p_0 for the correct value of p_1.

Regarding the volume of uncompressed air, V_0 is its volume measured at the pressure P_0, i. e., the actual volume of uncompressed air at its actual tension. If more convenient, however, we may use the volume of this air measured at standard barometric pressure, if we multiply it by p_0, the standard pressure. Thus, if we know the volume of uncompressed air measured at one atmosphere standard tension, we may use for the p_0 immediately following it the standard pressure 10.334 (kilos. per square meter), or 2,120 (pounds per square foot). By the law of the reciprocal nature of volume and pressure, the product thus obtained is the same as would be found by multiplying the volume of the same air at any other pressure by that pressure ($V_0 p_0 = V_1 p_1 = V_2 p_2$, etc.). Whatever pressure we use in getting the product $V_0 p_0$, however, we must use only the actual tension of the uncompressed air as the denominator in getting the ratio of compression ($p_1 \div p_0$).

Problem 56.

A blast furnace requires 2,615 cubic meters of air, measured at − 5° C., for every metric ton of pig iron made. Assuming outside barometric pressure 735 millimeters of mercury column, the efficient pressure of the compressed blast to be 1.0 kilogram per square centimeter (as measured in a blast regulating reservoir), a mechanical efficiency of the blowing engine of 90 per cent, of delivery of blast 82.3 per cent, and output 447 tons per day:

Required:

(1) The ratio of compression of the blast.

(2) The piston displacement per ton of pig iron made.

(3) The work of the blowing cylinders, per ton of iron made.

(4) The gross or indicated horse-power of the steam cylinders.

Solution:

(1) The effective pressure being 1.0 kilogram per square centimeter, represents $\frac{1.0000}{1.0334} \times 760 = 735$ millimeters of mercury. But the uncompressed air is at 735 mm. barometric tension, therefore, the total tension of the compressed air, p_1, is 1470 mm. of mercury, and the

$$\text{Ratio of compression} = \frac{1470}{735} = 2.0 \qquad (1)$$

(2) Piston displacement per metric ton of pig iron:

$$\frac{2615}{0.823} = 3,165 \text{ cubic meters.} \qquad (2)$$

$$= 111,560 \text{ cubic feet}$$

(3) The volume displaced must be the basis of calculating the power required, since subsequent losses of air (100 − 82.3 = 17.7 per cent) do not affect the work done in the blowing cylinder. This volume is 3,165 cubic meters, representing that volume of uncompressed air at −5° C. and 735 mm. pressure. The initial temperature of the air does not affect the work to be done, and we can either use its volume at 735 mm. tension or correct this to 760 mm. tension, just as

we chose. If we consider the volume at 735 mm. tension, then the product of volume and pressure is

$$Vp = 3.165 \times \left(10,334 \times \frac{735}{760} \right) = 31,755,000$$

If we first change the volume to standard pressure, we have

$$V_0 p_0 = \left(3,165 \times \frac{735}{760} \right) \times 10,334 = 31,755,000$$

The work done in compression, in the blowing cylinder, is, therefore,

$$
\begin{aligned}
W &= 3.45 \times 3,073 \times 10,334 \times \left[2^{.29} - 1 \right] \\
&= 109,554,750 \times \left[1.2225 - 1 \right] \\
&= \textbf{24,326,800} \text{ kilogrammeters.} \tag{3}
\end{aligned}
$$

(4) The steam in the steam cylinders does more mechanical work than would be represented by the compression of air in the blowing cylinders. In this case, we assume 90 per cent mechanical efficiency, or 10 per cent mechanical loss. The gross work of the steam is, therefore,

$$24,326,800 \div 0.90 = 27,029,800 \text{ kilogrammeters,}$$

or, in horse-power,

$$\frac{27,029,900 \times 447}{1440 \times 4500} = \textbf{1,865} \text{ horse-power.}$$

This amounts to 4.17 hp. per metric ton of pig iron made per day.

MEASUREMENT OF PRESSURE.

In making calculations of the work done in furnishing blast, as in the preceding problem, it is important to note how the pressure of the compressed air is measured. The real pressure is measured correctly by a pressure gauge only where the air is comparatively at rest, as on a pressure-equalizing reservoir. If the pipe communicating with a gauge is connected with a blast main, in which the velocity of the air is considerable, the pressure recorded will vary greatly with the direction of the end of this tube relative to the direction of the air current. The total pressure of the air in motion is the pressure which it exerts against the sides of the main, plus the pressure which has been used in giving it velocity. If the pressure gauge tube is cut off at right angles to the flow of air in the main, the pressure recorded is even less than the actual static pressure of the air against the sides of the main (because of suction effect), and does not include at all the pressure represented by the velocity. The only way to measure correctly in a main the total pressure which has been impressed upon the blast is to bend the end of the pressure tube until it is parallel with the axis of the main and faces the current of air. The gauge then records the static pressure, plus the velocity head, and gives the proper pressure to use in calculating the work done by the blowing engine. However, it is still preferable to put the gauge on a blast reservoir, if there is one, where the air is nearly at rest and velocity head approximates zero—for the reason that the velocity of air passing through a tube is greatest in the center and least against the walls, and it is difficult to place the pressure tube so as to measure the mean velocity. An approximation to the mean value is found by placing the end of the pressure tube not in the center but at one-third of the radius of the main from the center.

INDICATOR CARDS.

If the blowing engine cylinder can be tested by pressure indicator cards, then a different method of obtaining the work of producing the blast is furnished. The integration of the diagram gives the mean pressure on the piston during the stroke. Expressing this in kilograms per square meter or pounds per square foot, and multiplying by the area of the piston and the length of the cylinder, we get the work done per stroke; again multiplying by the number of strokes per minute we have the work done per minute, from which is

readily obtained the horse-power. These operations are usually combined in the formula:

$$\text{Work} = P \times L \times A \times N$$

If we observe that $L \times A \times N$ is the piston displacement per minute, the formula becomes:

$$\text{Work} = P \times \text{Piston displacement per minute,}$$

in which, it must not be forgotten, P represents mean pressure on the piston during the stroke, and is not to be confounded with gauge pressure of the compressed air. Such a formula is, therefore, totally inapplicable to finding the work done by a fan or rotary blower, in which only the final pressure of the compressed air is known. The mistake of so applying it is often made. When only the final pressure of the compressed air is known, the formula for adiabatic compression is the only correct one to use.

It may not be useless to call attention to the fact that when using the formula for adiabatic compression, the raising of the ratio of compression to the 0.29 power has to be done by logarithms:

$$\log \left(\frac{p_1}{p_0} \right)^{0.29} = \log \left(\frac{p_1}{p_0} \right) \times 0.29$$

If a table of logarithms is not at hand, a satisfactory approximation may be made by taking the cube root of the ratio, since

$$\sqrt[3]{\left(\frac{p_1}{p_0} \right)} = \left(\frac{p_1}{p_0} \right)^{0.33}$$

HEATING OF THE BLAST.

Air blast is commonly heated either continuously, by direct transmission of heat through metal or earthenware pipes, or discontinuously by the heating up of fire-brick surfaces, which are subsequently cooled by the blast. It is not within the province of these calculations to enter into a description of the various types of such hot-blast stoves, but to indicate the principles upon which the metallurgist can base calculations as to the efficiency of such stoves, and thus be prepared to find out which do the best work, and wherein lie the principal advantages or disadvantages of each type.

The efficiency of a hot-blast stove is measured by the ratio of the heat imparted to the blast to that contained in the air and fuel used and generated by combustion. It is a furnace whose useful effect is the heat imparted to the air, and all other items of heat distribution are more or less necessary losses. The problem is simplest when the stove is a recuperator (continuous type), using solid fuel. Then the item of heat generation is perfectly definite, since the amount of fuel used in a given time can be definitely determined. When the hot-blast stove receives gaseous fuel, however, from a blast furnace, the amount of gas received by the stoves is usually a very uncertain quantity, since only part of all the gas produced by the furnace is used by the stoves, and the question of what fraction is thus used is difficult to determine. In such cases, the usual method of comparing the sizes of the pipes leading gas to the stoves and those carrying gas to boilers, etc., affords but a very uncertain determination, since the draft and consequent velocity of the gas may be very different in the two sets of pipes. In such cases, knowing the total volume of gas produced by the furnace, not only the relative sizes of the hot-blast stove pipes should be noted, but also the relative velocities of the gas currents in the two sets of pipes. Another method is to determine the quantity of chimney gas passing away from the stoves into the chimney flues, by measuring the size of the chimney flue, temperature of the gases and average velocity; given in addition the chemical analyses of the chimney gas and of the furnace gas, the quantity of the latter being used can be calculated, using the carbon in the two gases as the basis of calculation.

Problem 57.

Statement: Air for drying peat in a kiln is heated from 0° C. to 150° C. by an iron pipe stove, the latter consuming dried peat, whose ultimate analysis is:

Carbon	49.70 per cent	
Hydrogen	5.33	"
Oxygen	30.76	"
Nitrogen	1.01	"
Ash	13.23	"

The calorific power of this peat is 4249, and by the combustion of 92.5 kilograms, 5122 cubic meters of air is heated to the required temperature. The products of combustion pass away from the stove at 200° C., and contain (analyzed dry) 14.8 per cent of CO_2, and no CO or CH_4 or other gas containing carbon.

Required:

(1) The heat generated in the stove.

(2) The heat in the hot air, and the net efficiency of the stove.

(3) The volume and composition of the products of combustion in the stove.

(4) The heat carried out in the chimney of the stove.

(5) The heat lost by radiation and combustion.

(6) The excess of air used in burning the peat.

(1) Heat generated in the stove:

$$4249 \times 92.5 \qquad = \mathbf{393,033} \text{ Calories (1)}$$

(2) Heat imparted to the air:

$$[0.303 + 0.000027 (150)] \times 150$$
$$\times 5122 \qquad = 235,907 \quad "$$
$$\text{Net efficiency} = \mathbf{60.0} \text{ per cent (2)}$$

(3) Volume of products of combustion:

Weight of carbon in fuel burnt —

$$92.5 \times 0.4970 \qquad = 45.97 \text{ kilos.}$$

Volume of CO_2 thus produced —

$$45.97 \div 0.54 \qquad = 85.13 \text{ cub. meters}$$

Volume of (dry) gas produced —

$$85.13 \div 0.148 \qquad = 575.20 \quad " \qquad "$$

Volume of N_2 and O_2 in products —

$$575.2 - 85.13 \qquad = 490.07 \quad " \qquad "$$

Volume of water vapor in products —

$$92.5 \times 0.0533 \times 9 \div 0.81 \quad = 54.78 \quad " \qquad "$$

Percentage composition of products of combustion:

	Moist.	*Dried.*
CO_2	13.5	14.8
N_2 and O_2	77.8	85.2
H_2O	8.7	...

To separate the nitrogen and oxygen would necessitate considerable calculation, and is not required just here, because the two gases have the same heat capacity per cubic meter, and therefore can thermally be reckoned together:

(4) Heat in the chimney gases at 200°:

CO_2	85.13 m³ × 0.4140 =	35.24
N_2 and O_2	490.07 m³ × 0.3084 =	151.14
H_2O	54.78 m³ × 0.3700 =	20.27

$$206.65 \times 200 = 41,330 \text{ Cal.}$$
$$\text{Proportion thus lost} = \mathbf{10.5} \text{ P. C. (4)}$$

(5) Loss by radiation and conduction:

$$100 - (60.0 + 10.5) \qquad = \mathbf{29.5} \text{ P. C. (5)}$$

(6) The separation of N_2 and O_2 in the products is not easy. It is best based on the consideration that part of these consists of the nitrogen of the air which was necessary for combustion (plus the nitrogen of the fuel) and of the excess air. The first can be calculated, and thus the latter obtained by difference, and then the percentage of air in excess determined.

Oxygen necessary for combustion:

$$C \text{ to } CO_2 = 45.97 \times \frac{32}{12} \qquad = 122.59 \text{ kilos.}$$
$$H \text{ to } H_2O = 4.93 \times \qquad = 39.44 \quad "$$
$$162.03 \quad "$$

Oxygen present in peat 92.5 × 0.3076   = 28.45 kilos.

Oxygen to be supplied	= 133.58	"
Nitrogen accompanying	= 445.27	"
Air necessary	= 578.85	"
	= 447.7	m³

Nitrogen from coal, 92.5 × 0.0101 = 0.93 kilos.
Total nitrogen from coal and necessary air = 446.2 "
Volume = 446.2 ÷ 1.26 = 354.1 m³
Total N_2 and O_2 in products = 490.1 "

Therefore, excess air   = 136.0 "

$$\text{Percentage of excess air } \frac{136.0}{447.7} = 0.303 \qquad = \mathbf{30.3} \text{ P. C. (6)}$$

Problem 58.

A blast furnace has three hot-blast stoves, two of which are always on gas and one on blast. Per long ton of pig iron produced there issues from the furnace (reduced to standard temperature and pressure):

Nitrogen	81,763	cubic feet	
Carbon monoxide	25,383	"	"
Carbon di-oxide	20,409	"	"
Water vapor	8,230	"	"

For the same quantity of pig iron made, 92.330 cubic feet (standard conditions) of air is heated in the stoves from —5° C. to 465° C. The hot gases reach the stoves at 175° C., are there burned by 10 per cent excess of air at 0°, and the chimney gases resulting (assume perfect combustion) pass out of the stoves at 120° C.

Required:

(1) The net efficiency of the stoves, assuming they receive 25, 30, 35, 40, 45 or 50 per cent of the gas produced by the furnace.

(2) Assuming that each stove radiates and loses to the ground one-third as much heat as the blast furnace itself (the heat balance sheet of the furnace showed 846,518 pound Calories thus lost per long ton of pig iron produced), what proportion of the whole gas goes to the hot-blast stoves, and what is the net efficiency of the stoves?

Solution:

(1) We will first calculate the efficiency of the stoves, assuming that they received *all* the gas produced, from which datum can then be obtained the efficiency, supposing any assumed fraction of the gas goes to the stoves.

Heat in the blast (—5° to 465°):

$$92.330 \times [0.303 + 0.000027 (465 - 5)] \times [465 - (-5)] =$$
$$92.330 \times 0.31542 \times 470 = 13,687,683 \text{ ounce Cal.}$$
$$= 855,480 \text{ pound Cal.}$$

Sensible heat in the hot gases (0° to 175°):

N_2 and CO	107,146 × 0.3077 =	32,969
CO_2	20,409 × 0.4085 =	8,337
H_2O	8,230 × 0.3763 =	3,097

Heat capacity per 1°	=	44,403 ounce Cal.
	=	2,775 pound Cal.
2,775 × 175	=	485,625 " "

Heat generated by combustion:

CO to CO_2 25,383 × 3062	=	77,722,746 ounce Cal.
		4,857,672 pound Cal.
Total heat available	=	5,343,297 " "

If the gas were all used in the stoves the efficiency of the latter would be only

$$\frac{855,480}{5,343,297} = 0.160 = 16.0 \text{ per cent}$$

With smaller proportions of the whole gas used the efficiency of the stoves calculates out as follows:

Using 50 per cent of the gas.......Efficiency 32.0 per cent

"	45	"	"	....	"	36.0	"
"	40	"	"	....	"	40.0	"
"	35	"	"	....	"	45.7	"
"	30	"	"	....	"	53.3	"
"	25	"	"	....	"	64.0	"
"	16	"	"	....	"	100.0	" (1)

All that the above analysis tells us is, that certainly over 16 per cent of the gas produced by the furnace must be used by the stoves; but if we can deduce any probable value for the percentage of the gas actually used, such as by measuring the several gas mains and the velocities of the gas in each, we can then reckon out the value of the efficiency of the stoves, with about the same degree of probability. Blast furnaces use from 33 to 60 per cent of the gas they produce in the stoves. If we assume 50 per cent, in this case, the efficiency of the stoves would be 32 per cent.

(2) There is another way of solving the problem, which is to either measure, calculate or assume the heat lost by radiation and conduction from the stoves; adding to this the heat going out in the products of combustion, and the net heat in hot blast, the sum is the total heat which has been brought into and generated within the stoves. But, all the gas would bring in and generate in the stoves 5,343,297 Calories; we can, therefore, find easily what proportion of all the gas is being used in the stoves. In requirement (2) we are told to assume that the three stoves lose by radiation and conduction 846,518 pound Calories per long ton of pig iron made, an amount equal to that similarly lost by the furnace itself. The heat in the chimney gases, at 120°, can be thus calculated:

Oxygen required $\left(\dfrac{1}{2} CO\right)$ = 12,692 cubic feet.

Air required	=	61,017	" "
Excess air used	=	6,102	" "
Nitrogen of required air	=	48,325	" "
Nitrogen already in gas	=	81,763	" "
Nitrogen in these two items	=	130,088	" "

Chimney products:

CO²	=	45,792	" "
H²O	=	8,230	" "
N²	=	130,088	" "
Excess air	=	6,102	" "

Heat in chimney gases:

CO²	45,792 × 0.3964	=	18,152 ounce Cal.
H²O	8,230 × 0.3580	=	2,946 " "
N² and air	136,190 × 0.3064	=	41,729 " "
Heat capacity per 1°		=	62,827 " "
		=	3,927 pound Cal.
Heat capacity per 120°		=	471,122 " "

If all the furnace gas were burnt in the stoves, 471,122 pound Calories would go up the stove chimneys. But, since only a part of the gas is so used, only a fraction of this amount of heat is lost to the chimneys. If we call X the proportion of the gases used, then 471,122 X will represent the chimney loss, and the total heat requirements of the stoves will be:

Heat in air blast	=	855,480 lb. Cal.
Heat in chimney gases	=	471,122 X "
Radiation and conduction	=	846,518 "

Total = 1,701,998 + 471,122 X lb. Cal.

The proportion of the total gases needed to supply this, X, is

$$\frac{1,701,998 + 471,122 \ X}{5,343,297} = X$$

whence

$$X = 0.349 = \textbf{34.9} \text{ per cent} \qquad (2)$$

and the net efficiency of the stoves is

$$\frac{855,480}{5,343,297 \times 0.349} = \frac{855,480}{1,864,812} = \textbf{45.9} \text{ per cent} \qquad (2)$$

Arithmetically, the finding of X can be simplified, perhaps, by considering that the chimney loss represents in any case 471,122 ÷ 5,343,297 = 0.088 = 8.8 per cent of the total heat received by the stoves, leaving 91.2 per cent to be applied to heating the blast and for radiation and conduction loss. The last two items, however, must amount to 1,701,998 Calories, and, therefore, the total heat requirement of the stoves is

$$\frac{1,701,998}{0.912} = 1,866,200 \text{ pound Calories,}$$

requiring

$$\frac{1,866,200}{5,343,297} = 0.349 = \textbf{34.9} \text{ per cent} \qquad (2)$$

of all the gas produced by the furnace.

In the above solution the only uncertain factor in the calculation is the radiation and conduction loss from the stoves, and this uncertainty does not largely affect the reliability of the result obtained, allowing that we have assumed an approximately correct value for this loss. All uncertainty could be dispelled, however, were the radiation and conduction losses measured directly. This could be accomplished by finding experimentally the temperature of the outside shells of the stoves, and calculating the external losses of heat by the laws of radiation and conduction; but in order to do this satisfactorily, it would be necessary to divide the shells of the stoves into zones, and determine the temperature and calculate the losses from each zone separately—a rather long operation, but one worth doing.

DRYING AIR BLAST.

The advantage of dried blast has been already discussed at length in these calculations. The advantage is due primarily to the higher temperature obtained when the moisture has been removed.

The means adopted commercially for drying the air have been those of refrigerating the uncompressed air, before its entrance into the blowing cylinders. This has the great advantage of furnishing the cylinders with cold air, and, therefore, of greatly increasing their blowing capacity, since the weight or quantity of air blown is proportional to the absolute temperature of the air entering the cylinders.

Illustration: Outside air being at 30° C., what increase in the amount of air furnished by blowing engines will result if the temperature of the air is artificially reduced to —5° C.? How much slower can the engines be driven, in the second case, in order to furnish the same weight of air as before?

The two temperatures are respectively 273 + 30 and 273 — 5 absolute, that is, 303 and 268. The engines, if run at uniform speed, would furnish 303 ÷ 268 = 1.13 times as much air in the second case, or 13 per cent more. If the engines were slowed down to 268 ÷ 303 = 0.884 of their former speed they would furnish the same amount of air; that is, they could be run 11.6 per cent slower. In fact, they could be run more than 11.6 per cent slower in the second case, and yet supply the same quantity of air, because at the slower running the delivery efficiency is somewhat higher.

The disadvantage of cooling the uncompressed blast is that it must be cooled much more, to eliminate from it a given percentage of its moisture, than if it were first compressed, and to obtain nearly dry air the moisture must be practically frozen out.

Illustration: Air at 30° C. and 85 per cent humidity is to be cooled until 95 per cent of its moisture is eliminated, without compression; to what temperature must it be cooled?

From the tables of aqueous tension, we find that the maximum tension which aqueous vapor can exert at 30° C. is 31.5 millimeters, which means practically that $\dfrac{31.5}{728.5}$ of a cubic meter of moisture accompanies $\dfrac{760}{760}$ of a cubic meter of air proper. If the humidity is 85 per cent, then this same quantity of air is accompanied by

$$\frac{31.5}{760} \times 0.85 = 0.0352 \text{ cubic meters}$$

of mo .ture, or, per cubic meter of air measured dry —

$$0.0352 \div \frac{728.5}{760} = 0.0368 \text{ cubic meters.}$$

If 95 per cent of this is removed by cooling, then the moisture left, per cubic meter of air measured dry, is

$$0.0368 \times 0.05 = 0.00184 \text{ cubic meters.}$$

And the relative tensions of air and moisture, to attain this dryness, must have been reduced to

$$1.0000 \; : \; 0.00184.$$

Since the sum of these tensions is always 760 mm. in the uncompressed air, the actual tensions of air and moisture will be

$$758.6 \; : \; 1.4,$$

that is, the temperature must be reduced until the moisture present can exert only 1.4 mm. pressure. This, on examining the tables of tension of aqueous vapor is found to be less than 0° C., in fact —15° C.

Problem 59.

Air at 30° C., carrying 85 per cent of its possible amount of moisture, is cooled to 0° C., and the moisture condensed to liquid water at that temperature. Barometer 760 mm.

Required:

(1) The percentage of the moisture condensed.

(2) The amount of heat to be abstracted from each cubic meter of original moist air (refrigerating effect).

(3) The percentage of moisture which would be condensed if the temperature were reduced to —5° C.

(4) The total heat to be abstracted, per cubic meter of original air, in the latter case.

Solution:

(1) From the preceding illustration we can take the figures that in the moist air taken, each cubic meter of air proper is accompanied by 0.0368 cubic meter of moisture. In the cooled air at 0°, the relative volumes of air proper and residual moisture will be as their relative tensions, viz.:

$$755.4 \; : \; 4.6$$

or

$$1 \; : \; 0.0061.$$

The moisture accompanying the given quantity of air is, therefore, reduced from 0.0368 to 0.0061, showing a condensation of 0.0307, equal to

$$\frac{0.0307}{0.0368} = 0.834 = \mathbf{83.4} \text{ per cent.} \tag{1}$$

(2) The air at 30° contains, as before figured out, air proper and moisture in the proportions

$$1 \; : \; 0.0368.$$

Or, in 1 cubic meter of moist air, in the proportions

$$0.9645 \; : \; 0.0355.$$

We have, therefore, to calculate the heat to be extracted from 0.9645 cubic meter of air proper, falling 30° to 0°, and from 0.0355 cubic meter of water vapor, falling 30° to 0° and 83.4 per cent of the latter condensing to liquid at 0°. The figures are, remembering that the volumes heretofore handled are at 30°:

Air proper:

$$0.9645 \times \frac{273}{303} \times 0.3038 \times 30 \qquad = 7.920 \text{ Calories}$$

Moisture, if all uncondensed:

$$0.0355 \times \frac{273}{303} \times 0.3445 \times 30 \qquad = 0.332 \quad ''$$

Heat of condensation:

$$0.0355 \times 0.834 \times \frac{273}{303} \times 0.81 \times 606.5 = 13.105 \quad ''$$

$$\text{Total} = 21.357 \quad '' \; (2)$$

(3) If the temperature were reduced to —5° C., the tension of the residual moisture would be 3.4 mm. of mercury, and that of the air proper 756.6 mm., their relative volumes would be in the same ratio, viz.:

$$756.6 \; : \; 3.4$$

or

$$1 \; : \; 0.0045,$$

showing that out of 0.0368 cubic meter of moisture originally accompanying 1 cubic meter of air proper. 0.0323 had been condensed, or

$$\frac{0.0323}{0.0368} = 0.878 = \mathbf{87.8} \text{ per cent.} \tag{3}$$

(4) The condensation is seen to be 87.8 — 83.4, or 4.4 per cent more, if the air is cooled to —5° C. A considerably larger amount of refrigeration, however, is required in this case, because the moisture would all be frozen. The 1 cubic meter of moist air at 30°, containing, as before calculated. 0.9645 cubic meter of air proper and 0.0355 cubic meter of moisture, would have 87.8 per cent of the latter condensed to ice, or 0.03117 cubic meter, and, therefore, 0.00433 cubic meter remaining uncondensed.

Air proper, 30° to —5° C.:

$$0.9645 \times \frac{273}{303} \times 0.3037 \times 35 \qquad = 9.237 \text{ Calories}$$

Moisture, if all uncondensed, 30° to —5° C.:

$$0.0355 \times \frac{273}{303} \times 0.3438 \times 35 \qquad = 0.385 \quad ''$$

Condensation of 0.03177 m³ to liq. at —5°C.:

$$0.03177 \times \frac{273}{303} \times 0.81 \times 605 \qquad = 14.025 \quad ''$$

Freezing of same, at —5° C.:

$$0.03177 \times \frac{273}{303} \times 0.81 \times 80 \qquad = 1.855 \quad ''$$

$$= 25.502 \quad '' \; (4)$$

The conclusion is, that an increased condensation of 4.4 per cent has been obtained by an increase in the refrigerating requirement of 25.502 — 21.357 = 4.145 Calories, or nearly 20 per cent. Another way of stating the comparison. is that when not freezing the moisture condensed, about 4 per cent of the moisture was condensed from each cubic meter of air for one Calorie of refrigeration, whereas, the removal of additional moisture by cooling below zero requires nearly one Calorie refrigeration for each additional per cent of moisture eliminated.

A practical conclusion is, that the expense of refrigeration might easily be justified down to 0° C., and yet be unjustified by the results when cooling below 0°.

Mr. James Gayley has, I believe, patented the scheme of refrigerating the air in two stages; first, nearly to zero, removing the moisture thus condensed as liquid, and then cooling the nearly dry air further, eliminating more moisture as

ice. In this manner, the amount of refrigeration required is reduced by the latent heat of solidification of the larger part of the moisture, and cooling below zero becomes profitable. The saving in the above example would be 80 Calories per kilogram on all the moisture condensed at 0°, viz.:

$$0.0216 \times 80 = 1.728 \text{ Calories.}$$

Cutting down the refrigeration required from 25.502 to 23.774 Calories, that is, enabling 4.4 per cent additional drying to be produced for 2.4 Calories additional refrigeration. This scheme of Mr. Gayley is founded on sound scientific as well as practical considerations.

The idea of cooling the compressed blast by moderately cool water, recently proposed, is also a very practical idea and founded on sound scientific principles. At a given temperature moisture cannot exert more than a maximum vapor tension. It follows that if we start with air saturated with moisture, at a given temperature, and compress it to double its initial tension, keeping its temperature constant, about half of its moisture must condense out. If, at the same time, it is artificially cooled, then more than half of its moisture will condense as liquid.

If we start with air not saturated with moisture, the compression, temperature being constant, will increase the tension of the moisture present until the air becomes saturated, after which increased pressure will cause condensation.

Illustration: Air at 30° C., 85 per cent saturated with moisture, is compressed. At what effective pressure does it become saturated with moisture, temperature remaining constant?

The moisture present is exerting 85 per cent of its maximum vapor tension at this temperature. Therefore, the tension must be increased in the ratio of 85 to 100, to make the air saturated, viz.: in the ratio 1 to 1.177. The effective pressure necessary to be applied is, therefore, 1.177 — 1.000 = 0.177 atmospheres (2.6 pounds per square inch).

Illustration: If air at 30° C., 85 per cent saturated with moisture, is compressed to one atmosphere effective pressure and its temperature kept constant, what proportion of its moisture will condense?

Before compression, the tension of the moisture being $31.5 \times 0.85 = 26.8$ mm., the relative volumes of air proper and moisture are as

$$733.2 : 26.8$$

or, as

$$1 : 0.0367$$

After compression, the tension on the mixture being two atmospheres (1520 mm.), and the tension of the uncondensed moisture being its maximum. or 31.5 mm., the relative volumes of air and uncondensed moisture will be as

$$1488.5 : 31.5,$$

or, as

$$1 : 0.0212.$$

The proportion of the original moisture remaining uncondensed, is therefore,

$$\frac{0.0212}{0.0367} = 0.578 = 57.8 \text{ per cent,}$$

and the amount condensed out = 42.2 per cent.

Problem 60.

Air at 30° C., and 85 per cent saturated with moisture is compressed to one atmosphere effective pressure (760 mm. of mercury), and simultaneously cooled by river water to 10° C. Barometer 730 mm.

Required:

(1) The percentage of the original moisture condensed.

(2) The weight of moisture remaining in the air, expressed in grams per cubic meter of dry air at standard conditions (i. e., per 1,293 kilograms of air proper).

Solution: (1)

Tension of uncompressed moist air   = 730.0 mm.
Tension of moisture present 31.5×0.85 =   26.8 "

Tension of air proper, uncompressed   = 703.2 "
Relative volumes of air proper and moisture = 1 : 0.0381
Tension of compressed moist air 730 + 760 = 1490.0 mm.
Tension of uncondensed moisture (maximum tension at 10°)   =   9.1 "
Tension of air proper, when compressed   = 1480.9 "
Relative volumes of air proper and uncondensed moisture   = 1 : 0.0061

Proportion of moisture condensed:

$$\frac{0.0381 - 0.0061}{0.0381} = 0.84 = \textbf{84.0} \text{ per cent.} \qquad (1)$$

(2) The relative volumes of air proper and uncondensed moisture are, as found above.

$$1 : 0.0061.$$

And the relative specific gravities of air proper and moisture are as the standard weights of 1 cubic meter of each, viz.: as

$$1.293 : 0.81.$$

It follows, therefore, that 1.293 kilos. of air proper (1 cubic meter at standard conditions) must be accompanied by

$$0.0061 \times 0.81 = 0.0049 \text{ kg. of moisture,}$$

or $$= \textbf{4.9} \text{ grams.} \qquad (2)$$

The original moist air contained, similarly considered,

$$0.0381 \times 0.81 = 0.0309 \text{ kg.}$$
$$= \textbf{30.9} \text{ grams.}$$

The Electrical Discharge in Air and its Commercial Application.[1]

By William Cramp and Sidney Leetham.

It was in 1903 that Mr. Sidney Leetham discovered. after experimenting with the bleaching of flour by means of ozone, that a much more powerful bleaching agent than ozone was produced if air that had been ozonized were passed through boxes in which electrical discharges between spark points were taking place. It was evident from the smell of the gas that the new product was different to the old, and some time was spent in noticing and attempting to ascertain clearly what this new product was. Dr. H. E. Armstrong made an analysis and about that time wrote: "I am much struck with the nature of the results obtained, viz.: the rapidity and certainty

FIG. I.—ELECTRIC DISCHARGE APPARATUS.

with which the effect is produced and the improved bleach as compared with that produced by oxides of nitrogen. I believe * * * that it is a joint effect of ozone and oxides of nitrogen, which I find are both present, though the total amount is not more than two parts in 10,000. I am satisfied that by this mixture an effect is produced which is so far better than anything that can be attained by either of the constituents as to be accounted a *new technical effect.*"
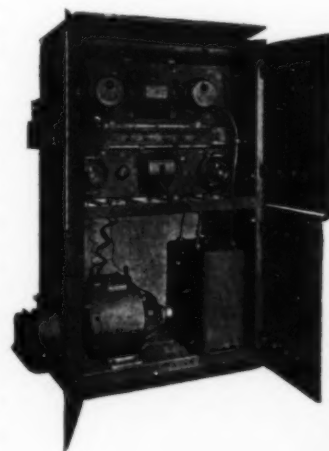
[1] A paper read at the York meeting of the British Association for the Advancement of Science.

CONSTRUCTION OF APPARATUS.

The apparatus as at present used is illustrated in Fig. 1, and consists of a steel plate case, in which is fixed an alternator, transformer, switchboard, ozonizer and sparking device; the whole being compact, self-contained and enclosed, occupies very small space and incurs no extra insurance risk. Besides the apparatus already mentioned, a small Roots blower is used for supplying air to be ozonized, and a small filter for cleaning this air. The action of the apparatus is as follows:

Pure air cleared from dust particles by passage through the filter is supplied by the blower to the ozonizer (situated behind the switchboard), where it becomes ozonized, and also to
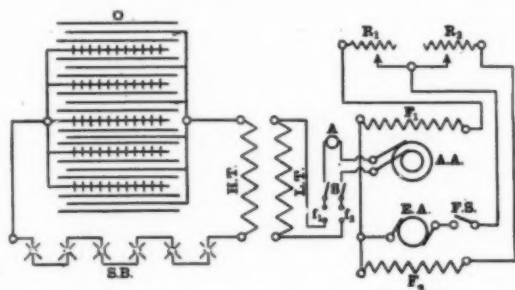
FIG. 2.—DIAGRAM OF CONNECTIONS OF THE APPARATUS, FIG. I.

some extent sterilized. The ozonized air then passes on to the spark box—seen across the middle of the switchboard—where a very small proportion of oxides of nitrogen appears to be produced by the sparks between the points in the box. From the spark box the air passes through a valve flange (seen on the left-hand end of the case) straight to the reels through which the product to be bleached is passing.

The actual electric circuits are as shown in the diagram of connections (Fig. 2); where the high-tension and low-tension coils of the transformer are denoted by HT and LT respectively; O is the ozonizer of the Andreoli pattern; SB is the spark box, in which are a number of spark gaps in series; AA is the alternator armature and EA is the exciter armature; F_1 and F_2 are the field coils, and R_1 and R_2 the regulating rheostats. It will be noticed that the ozonizer and spark box are in series, and this is a great advantage in rendering the apparatus automatic to a certain extent. For every increase of cur-
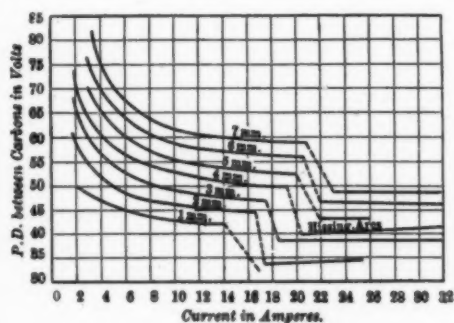
FIG. 3.—POTENTIAL DIFFERENCE AND CURRENT FOR DIFFERENT ARC LENGTHS (MRS. AYRTON). POSITIVE 11 M.M., NEGATIVE 9 M.M.

rent affects both ozonozer and sparks, so that within certain limits the proportions of the gas remain constant; though, of course, the yield becomes greater, as more fully discussed later.

It may be stated here that with the normal amount of air used, which is approximately 100 cubic feet per minute, the resulting gas, which issues from a point some 3 feet beyond the end of the delivery flange of the iron case, is made up about as

follows: Air, 40,000 parts by volume; ozone, three parts by volume; oxides of nitrogen, one part by volume (when four sparks are used, each 1-16 inch long, and the LT current is 8 amps.).

This result is the average of a large number of analyses made by Mr. F. S. Sinnatt, of the Manchester School of Technology, and will be seen to agree fairly well with Dr. Armstrong's rough estimate. It will, however, be clearly understood that variations in the above result are immediately introduced by change in any of the following factors: Frequency, air stream, distance apart of spark points and number of these, shape of points, temperature, current. Of these the last two influence the chemical phenomena chiefly. From a scientific point of view the interest lies in the question of how these various items affect not only the gas produced but also the type of discharge which produces it. We shall take the latter point first.

FORMS OF ELECTRIC DISCHARGES.

Hitherto all types of alternating electrical discharges have been divided into three great classes: (1) the ordinary alternating-current arc; (2) the high-tension discharge between spark points; (3) the silent discharge. These three have usually been considered as separate and distinct phenomena, but they have never been individually defined. In reality they are not separate, but all stages of the same phenomenon—namely, the breakdown of air as an insulator when strained electrically. Roughly, the three types have been usually classified by the effect which they produce. In this way the arc has been recognized as that type of discharge which gives great heat and light. The sparking discharge has been recognized as that which is much less hot, though still luminous, and is known to produce Hertz vibrations. The silent discharge is usually re-

FIG. 4.—SPARKS ONLY. THREE IN SERIES 1/16 INCH.

ferred to as that which produces ozone. Now, if a pair of metal points be insulated and separated in air by a small distance, and an electric potential difference be applied across the gap, we have the following series of events as the pressure is increased:

(a) The air is put into a state of stress.

(b) Small conducting paths appear through the air as the resistance gives way, giving rise to small blue streamers issuing from the points.

(c) The blue streamers get thicker, eventually joining the points up.

(d) The thicker streamers become a discharge very like the ordinary arc. At the final stage the points heat up, and the current passing may be gradually increased till the discharge is practically the alternating-current arc.

Throughout the changes given above the relation between current and e. m. f. across the gap is very remarkable. It has been known for a long time that an arc, either direct or alternating current, cannot be maintained on a constant potential circuit unless a steadying resistance or its equivalent is kept in series with it. This has given rise to discussion as to whether a back e. m. f. is present in the arc or not, though it is generally held now that change of air resistance alone is sufficient to account for the peculiarities observed. Whether a back e. m. f. exists or not hardly comes into the province of this paper; but it is perfectly certain that the *apparent* resistance of the arc changes as the current through it changes. In the case of ordinary arc lights the results immediately met
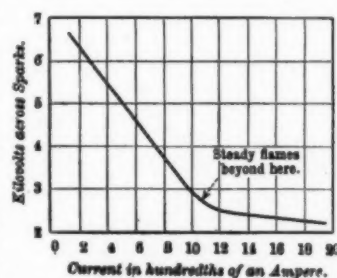
with are generally very like those in Fig. 3. which represents the relationship between e. m. f. and current in the direct-current arc, as given by Mrs. Ayrton in her book *The Electric Arc*.

Now, the very same sort of relationship is found to exist with both the other forms of discharge. It will be recognized that the cycle of changes given in *a, b, c, d* above includes not only the spark discharge but also the so-called silent discharge. In Figs. 4 and 5 are shown curves connecting the e. m. f. and current for cases which include both the silent and the spark discharge. It will be seen that just as in the case of the arc the fall of potential is very rapid as the current increases, but finally settles down until it almost becomes proportional to the current.[2] The diagrams not only show the agreement between the shape of the curves of Figs. 4 and 5 and that given in Fig. 3. which is very important, but also emphasizes the fact that it is very difficult to draw any hard-and-fast lines between the different types of the discharge.

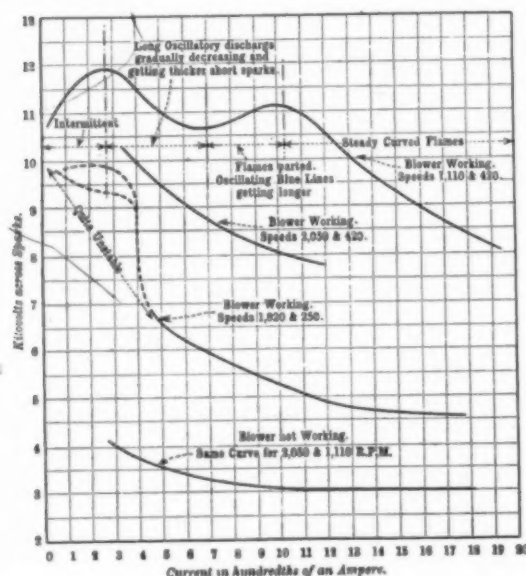It should be explained that as it was desired to act upon

FIG. 5.—FIVE SPARKS, EACH OF 1/16-INCH GAP.

air with the various forms of discharge a current of air had to be kept passing through the apparatus. This is why most of the curves above are taken with a certain air velocity, which is given in terms of the blower speed. Thus in Fig. 5, the numbers 420 and 250 refer to the speed of a 2½-inch Roots blower, and correspond to an air stream through the spark box of about 3,200 feet and 1,900 feet per minute respectively. The effect of this air velocity is (as shown) to increase the e. m. f. with a given current; but this will be discussed more fully directly. The earlier portion of the curves—that is, those parts in which the e. m. f. is high—usually refer to that discharge which produces chiefly ozone. Directly the curve has turned round, so that there is no longer a large fall in e. m. f. for a given current, very little ozone is produced.

It is clearly seen from the curves: (1) That the potential difference across the spark-gap gradually decreases as the current increases, showing clearly that the resistance of all electric discharges varies in a similar manner to that well known to exist in the case of the ordinary arc.

(2) That the character of the product of the discharge depends upon the voltage at the terminals for a given current; thus with the conditions shown in Fig. 4 practically no yield

[2] In all the curves connecting e. m. f. and current, where the e. m. f. is in kilovolts, the current is in hundredths of an ampere.

of oxides of nitrogen occurs until a point is reached marked with an arrow on the diagram. To the right of this arrow the discharge would be a small but rather hot arc, were it not for the presence of the air stream which blows the discharge into a short flame. In other words, up up to this point the discharge is to be considered practically as a silent discharge, afterwards as the so-called sparking discharge. The change, however, from one form to another takes place fairly gradually.

(3) Any character of discharge may be obtained by simply regulating the fall of potential at the discharge points or terminals, so as to fulfil the following requirements: Since the resistance (or impedance) of the air gap

FIG. 6.—SCHNELLER OZONIZER.

across which the spark passes appears to depend not only upon its length but also on the current passing (being lower with a larger current) it follows that if there were a constant pressure on the arc, having once started the discharge, the current would rise till the product $c \times R = E$, where R is the resistance or impedance of the arc, E the applied potential difference and C the current. If R tends to decrease faster than C rises, the conditions are quite unstable and result in a long series of flashes across the points, which were observed often in the case of these experiments. These flashes are produced by a large rush of current which is only limited by the armature reaction of the generator. In consequence of this, beyond a certain point the e. m. f. and potential difference of the latter fall, so that the current almost instantly falls to zero. As soon as this has happened the e. m. f. rises again, the spark is re-established, another rush of current takes place with a similar result. Often this would take place as frequently as sixty times a minute. To steady the discharge then it is only necessary to arrange the circuit so that an increase of current shall produce at the spark terminals a fall of potential difference sufficiently great, and in this way, by proper adjustment of the circuit, a perfectly steady result will be obtained.

The only other conditions necessary for producing and maintaining the discharge are (1) that the maximum potential difference of the e. m. f.

FIG. 7.—ALTERNATOR CHARACTERISTIC.

wave shall be capable of crossing the spark gap; (2) that the current ensuing shall be great enough to so lower the resistance of the gap that the vapor column set up shall not entirely die away before the zero point is crossed and the current re-established.

The adjustment of the circuit just shown to be necessary may be carried out in many ways. In the author's apparatus it is obtained by the use of a heavy synchronous armature impedance, but it may be almost as well obtained by resistance or choking coils. The higher up the scale the discharge the
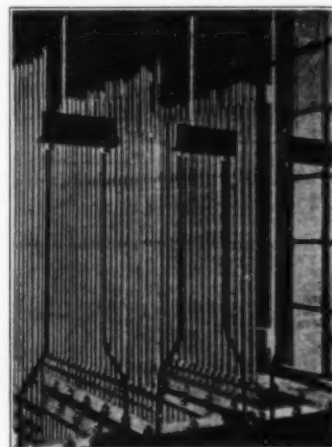
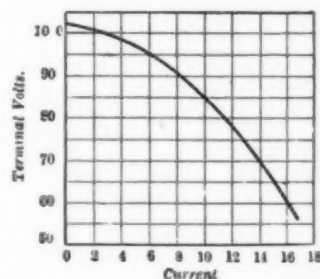greater must be the resistance employed; thus, if a silent discharge is required, the resistance drop will need to be from one-third to one-half of the terminal voltage.

An instance of such an ozonizer is the well-known Schneller ozonizer shown in Fig. 6, where the potential drop is obtained by means of a tube of glycerine, through which the current passes to those plates, between which the silent discharge takes place. If the ordinary constant potential arc is required, an impedance drop of about one-quarter the terminal voltage is used, while the characteristic of the alternator used by the authors for their purpose is as shown in Fig. 7. The amount of steadying resistance for any type of discharge is affected by:

1. *The Frequency Employed.* — The higher the frequency the less likely is the discharge to be interrupted, and hence the lower is the pressure for a given current. This is well shown in Fig. 5. It is, however, curious that in some cases for very small currents the pressure required is actually raised by raising the frequency. In the apparatus
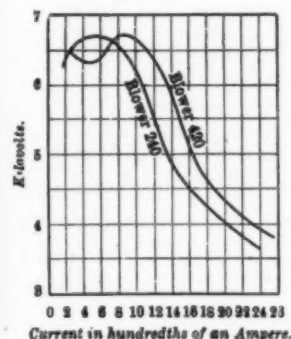

FIG. 8.—EFFECT OF AIR VELOCITY.

as used by the authors, where the ozonizer and spark box are in series, though, as is shown later, the yield of ozone per amp. may be increased by raising the frequency, yet because the spark seems to have some difficulty in starting, and because the instability of the circuit does not seem to be reduced by higher frequencies, a practical limit is reached at about 150 to 200 periods per second.

2. *Air Velocity.* — The general effect of increased air velocity is to increase the apparent length, and hence, also, the apparent resistance of the spark, and with high air velocities the spark becomes blown out or extended into a flame. The general effects of the air velocity are shown in Fig. 5, and again in Fig. 8. In these diagrams the meaning of the figures 420, 250, 240 has already been referred to. Fig. 5, however, has a second set of figures upon it, viz.: 1,110, 2,050 and 1,820. These refer to the alternator speeds, and correspond to frequencies of 148, 273 and 243 respectively. In this way, while Fig. 8 shows the effect of change of air velocity only, Fig. 5 combines with this the effect of change of frequency. The obvious deductions from these curves are that higher frequencies conduce to lower the
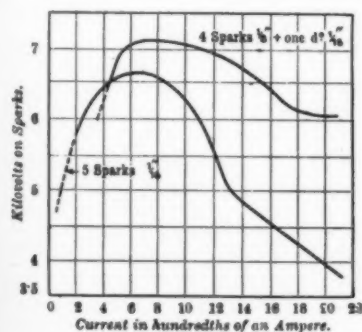

FIG. 9.—EFFECT OF SPARK LENGTH (BLOWER 240 REVOLUTIONS).

pressure for a given current, and higher air velocities conduce to higher pressure for the same current.

It may be observed that, besides these obvious results, it is also found that a high air velocity sets up very serious oscillations in the circuit, which have many times been responsible for breaking down the high-tension transformers used in these experiments One would almost expect this result from the fact that the higher the air velocity the more likely is the spark to be very unsteady and very often extinguished. These

oscillations show themselves in the curves in giving rise to the unstable portion and causing it to exist at higher currents; and, finally, on account of their disastrous effects it was found necessary to limit the air velocity in the apparatus as at present used to a maximum of 2,500 feet per minute, with the distance between spark points, say 1/16 inch.

3. *Distance Apart of Spark Points.* — Many tests were taken with different spark lengths, as, for instance, five sparks 1/16 inch long in series were compared with four sparks of 1/8 inch long, and one of 1/16 inch. In the latter case the oscillations in the circuit are found to be greater than with the former, and this general result is true whenever the length of spark is increased. Again, the potential difference with the long spark gaps is always greater than in the case of the shorter, but this effect is not proportional to the number of sparks in series in the apparatus, nor so marked as the increase in oscillations, especially with low currents. So important is the latter that in certain instances it is not possible to measure the voltage across the sparks at all.

It might be expected that the voltage would be almost proportional to the number of sparks in series, but this is not found to be the case at all. On the contrary, Fig. 10 shows that the voltage required for three sparks (each 1/16 inch long) in series, is quite different to that required for one spark 3/16 inch long; further, Fig. 9 shows that four sparks, 1/8 inch long in series, and one of 1/16 inch long, do not take, with small currents, anything like twice the voltage of five sparks 1/16 inch long, as might have been expected. From a
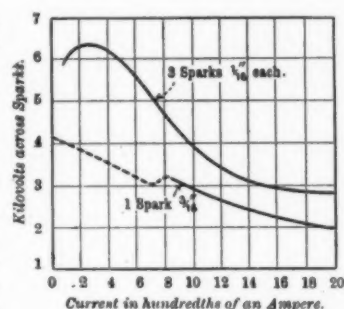

FIG. 10.—EFFECT OF SPARK LENGTH (BLOWER 265 REVOLUTIONS).

great number of experiments the phenomena above detailed seem to be largely explained by the following considerations:

1. If the spark is a long one the air velocity has more effect upon the discharge, since the points protect it less.

2. Any capacity effect due to the points themselves is more marked when the points are close together.

3. If a vapor column is set up, the longer it is the more easily is it cooled.

These three causes, even taken with others referred to above, do not explain all the effects observed. We must assign to other causes the small increase of pressure for increase of spark length. for instance; also the comparative ease with which the discharges start if no air stream is present (see Fig. 5). The tests given below upon the question of ionization will perhaps afford a clue to these points. In the meantime we may mention that the surface leakage over the insulating porcelain has many times been responsible for starting one spark of a series before the others begin, so that it is usually found that four sparks 1/16 inch in series will start at a much lower voltage than one spark 1/4 inch long. But this fact alone will not explain the phenomenon that to restart the discharge after it has been running for some time requires a much lower pressure than to start the discharge at first; which must also be referred to the state of so-called ionization in which the gas exists.

Effect of Shape of Points. — The shape of the point changes very considerably the apparent resistance of the discharge, and also, in consequence, the type of discharge produced.

It is well known, in connection with high-tension discharges, that the sharper the points between which the current passes the lower is the pressure at which the discharge will commence.

As an example of this we can give some results obtained at the Manchester School of Technology, by Mr. Bertram Scott. In these tests three types of electrodes were used, viz.:

1. Flat electrodes with rounded edges (in pairs).

2. Flat electrodes with sharp edges and spherical electrodes (one of each).

3. Sharp or pointed electrodes (in pairs).

The results, so far as they influence the pressures used in this apparatus, are as follows:

1. Flat electrodes with rounded edges.

Kilovolts.	Sparking Distance in Cm.
18	1.8
29.5	3.9
40	6

2. Flat electrodes with sharp edges and spherical electrodes.

Kilovolts.	Sparking Distance in Cm.
15	2
24	4
29	5
38	7
46	9

3. Sharp electrodes.

With these it was found that the effect of the sharpness was more marked the less the angle at the apex. The most marked results were obtained with needle points, and it will be noticed that, with such shaped points, the voltage required for a sparking distance of 2 cm. is about half that given in the first case. The figures are as follows:

Kilovolts.	Distance in Cm.
9	2.0
20	4.0
28	6.8
36	9.0
45	10.9

All the above results, of course, would change slightly with change of wave-form; in these cases an alternator was employed whose wave had a form factor of 1.54, so that the shape was approximately sinusoidal. Fig. 10A illustrates these readings graphically.

The voltages given are not applicable to the actual apparatus under consideration, since no air current was present except that which would be produced by the actual heat of the discharge; and, since the results were taken when the points were vertical, this would have very
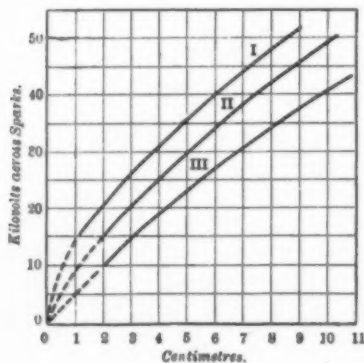

FIG. 10A.—SPARKING DISTANCE IN AIR.

little effect. When, however, an air current plays on the discharge, a result similar to the above is always experienced, but the voltage for a given sparking discharge is higher, the actual increase of voltage being of the order of that shown in Fig. 5. It was, therefore, most advantageous for this particular plant, where low voltage is desirable, that the shape of the points should be as sharp as possible. The final shape has been determined by the question of the life of the spark points—that is, they are so proportioned that they will dissipate the heat generated between them fast enough to necessitate no adjustment of the points, at any rate more often than once a month. The point used now is made from a screw ½ inch in diameter, with an apex angle of 90°, very slightly rounded at the extreme point. It

is found that up to 0.2 amp., with the normal air velocity as already given, six pairs of these points in a spark box do not materially change when at work night and day for a period of three weeks.

The foregoing discussion has been confined chiefly to those portions of the curves where the discharge produced is of the type known as "sparking." It is necessary now to refer to the upper parts, where, as has been already said, ozone is produced. The figures show quite clearly that in these steep parts the discharge is very unstable, and in consequence a large steadying resistance is necessary, for the current is, in any case, extremely small. This large steadying resistance (or impedance) in commercial ozonizers takes the form of either:

FIG. 11.—SPEED 1,200.

1. A dielectric between the points.

2. Very high resistance in series with the points, such as the glycerine tubes of Schneller.

3. A capacity in series with the points.

Examples of No. 1 are the ozonizers of Siemens, Andreoli, Elworthy, etc., which usually consist of two conductors, either plain or carrying points separated by mica or glass. In cases like this the fall of potential, which has been shown is necessary to maintain this silent discharge. takes place across the dielectric itself.

Where the points are placed upon sheets, and separated by sheets of mica (Andreoli), the ozonizer may have a large capacity, and in this case the effect of the breakdown of the resistance is very clearly marked. By the laws of condensers, if the ozonizer works as a capacity alone, the current would be proportional to the terminal potential difference; and in this case, therefore, the "curve" connecting voltage and current would be a straight line. If, then, such a curve be drawn for an ozonizer, and it is found to depart from the straight line, we should expect to find the yield of ozone increase as the curve turns over. This effect is clearly shown in Fig. 11, and it was always found that the yield of ozone increased as the curve departed from the straight line, until the vigor of the discharge caused the temperature to rise to such an extent as to partially destroy the ozone produced.

Ozonizers of the second type are not, as a rule, so efficient as the former. They are, however, easy to construct, and, as a rule, less bulky. An ozonizer of this type was constructed by Mr. Cramp, which consisted of a number of serrated strips of aluminium, placed with their serrated edges about ½ inch apart. It was found that the minimum air gap between these edges, at which a steady, silent discharge, producing large quantities of ozone, could be obtained, was about 7/16 inch; and in the experiment in question 9/16 inch actually gave about the best result.

In order to steady the discharge a glycerine resistance had to be included in the circuit. of such dimensions that the drop across the resistance was practically equal to the drop across the air gap. By gradually lowering this resistance the discharge could be changed from the silent distributed discharge to the located spark. A large fall of potential was always observed as the discharge changed from one form to the other.

Ozonizers of the third form are not made commercially, and the reason is probably that with any tendency of the air gap to break down, the condenser immediately discharges through the circuit, assisting the breakdown; hence the type cannot be
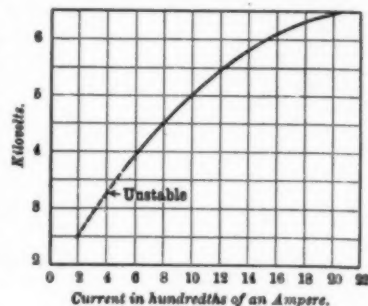
recommended, but it has been found possible to use, in series with the gaps described above, a small condenser which, by the fall of potential which it produced across the gaps, is enabled to a certain extent to steady the silent discharge. Of course, the capacity of the condenser must be of such a value that it cannot (by causing a leading current) raise to any extent the alternator voltage by means of armature reaction.

Summarizing now the general results of this investigation we have:

(*a*) All the types of electrical discharge in air behave similarly, and may be steadied by similar means.

(*b*) Between a pair of spark points in air any type of discharge may be obtained by suitable regulation—from the silent type producing ozone down to the alternating-current arc.

(*c*) Increasing the number of air gaps in series raises the voltage, but not proportionally to the number of gaps.

FIG. 12.—IONIZATION EXPERIMENTS.

(*d*) An air current, impinging on the electric discharge, increases the mean length of path of the discharge; with large currents, blows it into a flame, renders the spark unable to pass without increased pressure and always sets up oscillations in the circuit.
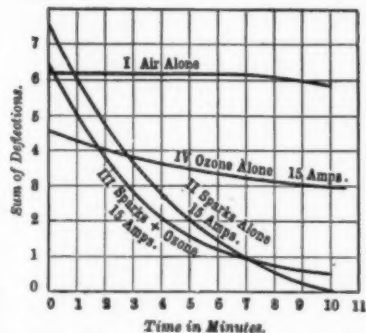
(*e*) The effect of increasing the frequency is to lower the voltage required to maintain the spark, but this does not necessarily hold at starting.

ELECTROCHEMCAL EXPERIMENTS.

So many of the results obtained, both electrically and chemically, seemed inexplicable on ordinary grounds, that it was thought advisable to try the gases produced by the electrical discharge for *ionization*.[*] Accordingly, a series of curves were taken, which show the time required to discharge a good electroscope:

(*a*) By allowing the stream of air alone to impinge on the knob of the electroscope.

(*b*) By substituting for this a stream of air which had passed through the ozonizer.

(*c*) By substituting a stream of air which had been modified by passing through the spark box.

(*d*) By combining *b* and *c*.

The results are very clearly shown in Fig. 12. They indicate that the air, after having passed through the chambers in which electrification was proceeding, is always in a state of ionization. This result is much more marked in the case of air issuing from the spark box than in the case of air which has simply passed through the ozonizer. It is to be considered in connection with the chemical phenomena, but may also be discussed here with reference to the electrical effects.

Suggested Further Theoretical Explanation of Results Obtained.—It seemed almost impossible to imagine that these discharges, which require so small a current, could, by any possibility, produce enough heat to set up a vapor column sufficient to maintain a conducting path for the electric current; but, on the other hand, in the absence of the vapor-column theory, there seemed to be no reason why, first, the discharge should be more difficult to start when the air current was flowing, and, secondly, why it should be so much more difficult to maintain with an air current. Admit, however, that ionization is

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[*] The term "ionization," as used throughout, indicates simply capability of discharging an electroscope.

established and we immediately have an explanation for all the phenomena.

Thus, under electrical stress, the air is ionized between the points, and begins to tend to conduct. Small currents make their appearance as blue lines, but whether these blue lines are actually heated particles or not cannot be determined. Further increase of the current results in further ionization, with a better conducting path; but this conducting path is, under any circumstances, easily removed if a current of air is maintained past and around the points. Thus, the discharge would be more difficult to start and more difficult to maintain. Going still a step further we get towards the ordinary arc, and find that a vapor column is set up, which, of course, continues to behave very much as the ionized air column already suggested.

This is, in brief, the theory put forward by the authors to explain the facts already related, and it accords well with previous knowledge of the same subject. Of course, "ionization" would be immediately admitted by many as sufficient explanation for the whole of the phenomena, and we wish to insist upon the point that without some such theory some of the above facts are inexplicable, especially the point that the discharge starts more easily after it has been at work some time and then extinguished, than it does when first set to work. This characteristic is very marked with low air velocities and when the time between stopping and restarting is short. The same may be noticed with a high-tension electrostatic voltmeter. If it flashes over once, the case must be opened and fresh air introduced, or it will go over again at a comparatively low pressure. We think also that this phenomenon will almost certainly account for the extraordinary differences in so-called "sparking lengths," which have been so often observed and commented upon. Such differences have often been put down to damp and dust, but the authors' experience is that these factors will not altogether account for them. More especially the chemical results, the union of oxygen and nitrogen particularly, seem impossible without reference to some such theory, as will be seen presently.

CHEMICAL PHENOMENA.

It has hitherto been usual to speak of the silent discharge as though it were a perfectly well-known effect, producing a chemical result, well defined. The following experiments will dispel this idea: If an Andreoli ozonizer, such as that whose characteristic is shown in Fig. 11, be connected to alternate-current mains, and the pressure be gradually increased, it is found that a violet glow is set up between grids and mica which produces an excellent yield of ozone; increase of pressure increases the yield of ozone up to a certain point, beyond which the discharge becomes gradually more yellow, and finally quite a large percentage of oxides of nitrogen is produced, the yield of ozone being diminished. Whether ozone is really formed and afterwards destroyed, or actually never formed, is uncertain. Further increase of current still further increases the yield of oxides of nitrogen, though usually by this time long leakage discharges appear over the dielectric.

The effects are still more marked if an ozonizer without a dielectric other than air be used, as then the discharge can be gradually increased till practically no ozone is produced: thus the silent discharge becomes the sparking discharge, yielding chiefly N_2O_4; and however much the current be increased after this, even to the flaming arc, the gas produced is still N_2O_4. We have found no type of discharge, however silent, which yields no oxides of nitrogen.

We can offer no explanation whatever for the production of ozone by the initial types of discharge. But there are some suggestions we can make as to the formation of oxides of nitrogen. It has been generally assumed that oxides of nitrogen are formed electrically by nitrogen burning in the air, the heat necessary being supplied by the flame of the arc or spark, as pointed out in 1898 by Crookes. Now, the temperature of burning nitrogen is supposed to be about 2,000° C.; and though

it is impossible to see if this temperature ever exists in the sparking discharge, it seemed almost incredible that such could be the case. In order to try and settle this point, recourse was had to the following rough tests:

Temperature Effect.—A spark box with five pairs of points 1/16 inch apart was placed in circuit and the current adjusted to 0.1 amp. Tests were then made while the spark box was cold (20° C.), and again when heated to about 120° C., but no definite increase in the percentage of oxides of nitrogen was observed. It would therefore seem that the yield is not altogether a matter of temperature. With four 1/16-inch sparks in series, an air velocity of 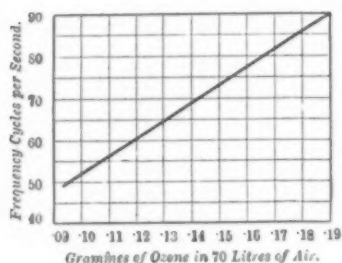2,000 feet per minute, and a current of 0.06 amp., the yield of oxides of nitrogen was 1 part in 40,000, as tested by Mr. Sinnatt many times.

Again, it is always found that when air with a small percentage of ozone is passed through the spark box the chief production of oxides of nitrogen does not take place in the spark box, but a little further on, in our case after the gas has passed through about 3 feet of pipe; pipe, too, which is perfectly cool. Or again, if in such a case the small sparks be replaced by white-hot Nernst filaments, no oxides of nitrogen are formed at all. And if further confirmation of the formation being independent of the temperature be needed, we can say that if pure oxygen mixed with 2 per cent of nitrogen be sent through a water-cooled Berthelot ozonizer, peroxide of nitrogen is still found to be present.

FIG. 14.—VARIATION IN YIELD OF OZONE, WITH FREQUENCY.

Current.—On the other hand, it is always found that the yield of oxides of nitrogen does not increase proportionately to the current, but more slowly. Indeed, in the spark box above referred to there is scarcely any change in the yield of oxides of nitrogen between 15 and 25 amps., which is very remarkable, inasmuch as not only is the current so much greater, but the temperature is also so much higher. On the other hand, between 5 and 10 amps. the yield is very much increased.

The reasons for these effects the authors consider to be as follows:

The best yields per ampere are always found to exist when very thin arcs are used, and this is confirmed by Bradley and Lovejoy, in America. That means, the air used must have easy access to the sparks if a large yield of oxides of nitrogen is desired; this condition accounts for the amount produced not being proportional to the current.

Now, in Fig. 12 it has been shown that the air modified by a sparking discharge is more highly ionized than that obtained by a silent discharge. Hence we suggest that ionization of the air allows of the combination of oxygen and nitrogen at fairly low temperatures to produce oxides of nitrogen, but it is very necessary that the air should be in intimate connection with the discharge to become thoroughly ionized.

This theory would seem to be well supported by the fact that replacing the sparks by apparatus which must surely be hotter—such, for instance, as a Nernst filament or a white-hot electric radiator—has no effect at all.

With regard to the effects produced on the gas by electrical variations in the circuit, it may be said that a great number of experiments have been carried out, but only the general results can be given here. These are:

Increase of frequency increases the yield of ozone, as shown by Prépognot (Fig. 14), and lowers the pressure for a given current through the spark box.

Increase of air velocity does not seem to lower the yield, but only the concentration.

Any increase in spark length increases the yield of oxides of nitrogen.

So much for the independent effects of different types of discharge. We come now to the most important part of the paper, viz.: the discovery that, though the gas produced by the sparks (N_2O_4) is valuable as a bleaching and sterilizing agent, and the gas produced by the ozonizer (ozone) is valuable in the same way, a combination of the two is far more valuable than either.

Reference to the first part of this paper will show the arrangement of the apparatus by which the Leetham gas is produced. It is obtained by passing air modified by an ozonizer through a box in which a sparking discharge is produced. An analysis of the gas produced has already been given, and it only remains to discuss its peculiar characteristics.

It has been pointed out as a curious fact that the chief modifications produced by the spark box are not discernible at the end of the spark box itself, but at a point in the pipe situated about 3 feet therefrom. This supports the theory already given for the production of N_2O_4. Beyond this 3 feet or 4 feet the gas analyses show no change, and it is an undoubted fact that, even after the gas has passed through many feet of pipe, ozone and oxides of nitrogen are still traceable. We regard this as very important, for eminent chemists (Sir James Dewar and others) have stated again and again that such a state of things is impossible; *i. e.*, that oxides of nitrogen and ozone cannot exist side by side. This simultaneous existence of two gases, well known to be mutually destructive, is probably the key to the whole extraordinary activity of the compound. As an instance of the great effect the gas has, it may be said that modified air, having a composition as shown in section I., will, if supplied at the rate of about 100 cubic feet per minute, bleach to a beautiful white color as much as 3 tons of flour an hour; a wonderful effect when the proportions of bleaching agents present are considered.

In order to try and discover the means whereby this electrical product yields such astonishing effects, very many experiments have been carried out both by the authors and Mr. J. S. Peachey, of the Manchester School of Technology. It is of interest to inquire, firstly, whether the bleaching action is due to oxidation. In order to test this, ozone, most carefully freed from oxides of nitrogen by thorough washing with pure concentrated sulphuric acid, was allowed to come into contact with flour. *Result: the flour was bleached.* An exactly similar effect was produced if the coloring matter of the flour was separated from the other constituents and treated with pure ozone. Therefore, the action may be ascribed to oxidation.

FIG. 13.—IONIZATION EXPERIMENTS.

Secondly, it is interesting to know whether the ozone and oxides of nitrogen act similarly as bleaching agents. So far this is not quite certain; but it is perfectly certain that the ultimate effect of the two bleachers is different. For ozone, however often applied, never has any other effect than that of bleaching, while oxides of nitrogen only bleach up to a certain point, beyond which they turn the flour darker and darker until it is a sepia color. The latter effect is probably due to the presence of nitric acid.

So far as we have yet discovered oxides of nitrogen and ozone bleach flour similarly, though the former has other effects besides that of bleaching.

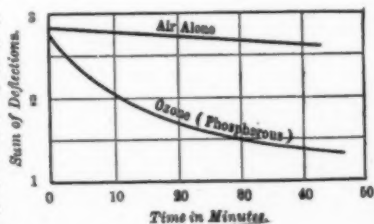Thirdly, we ask why are the two gases when electrically

produced so much more powerful than either gas alone.

Two theories are possible. (1) That the little proportion of oxides of nitrogen acts as a carrier between the ozone on the one hand and the flour on the other. It may be that by such means ozone is split up more easily, and the authors have certain reasons for inclining to this view. The action is then oxidation, but partially catalytic oxidation.

(2) That by passage through the spark box the ozone is rendered much more active because much more highly ionized. Fig. 12 shows how much more ionization takes place in the spark box than in the ozonizer. It was thought that this question might be settled once and for all by producing the ozone chemically instead of electrically. Pure ozone was, therefore, carefully prepared by Mr. Peachey by means of the well-known action of phosphorus, and this was found to bleach effectively; but on testing with the electroscope it was also found to be in a state of ionization, as shown in Fig. 13, so that the test was quite inconclusive. Work on this subject is still in hand, and the authors can only ask those chemists who have any experience of this kind of work to express their opinions of the possibility of each of the theories above suggested.

We may, however, collect, for the benefit of the commercial chemist, the results which have been obtained in this investigation and which will be of use to all those who are seeking to solve the problem of the electrical fixation of nitrogen or the economic production of ozone.

The conclusions to which our experiments point are:

(*a*) In order to obtain good yields of oxides of nitrogen from the air, it is not essential that a very high temperature should be used. Very thin electric discharges existing between many pairs of points (the latter being as far apart as insulation will allow and supplied by alternating current of high frequency) will give, probably, the most economical results. By this means long flames of burning nitrogen may be produced which do not appear to have a temperature approaching that of the arc, but yield, nevertheless, as much oxides of nitrogen with a smaller expenditure of power. Good results are to be looked for, not by increasing the current supplying those points so much as by increasing the number of pairs of points used.

The use of a current of air to extend these discharges is certainly to be advocated, but the limit of the velocity of this air current is determined by the oscillations set up in the circuit thereby; for above a certain point no commercial insulator will stand the effect of these latter.

The points used should be conical in shape, of such proportions that they do not readily burn away. Steel is, perhaps, the best material.

(*b*) In order to obtain good yields of ozone electric discharges should be allowed to take place between edges or points, these discharges being controlled by a high steadying resistance or impedance, so that they cannot possibly develop into that form of discharge which is so concentrated that it may be blown into a flame. An alternating current of high frequency should be used, and to avoid the production of oxides of nitrogen, the air supplied should be dry, clean and cold, and every precaution should be taken to keep the whole apparatus cool, as, with high temperature, ozone is immediately split up. The current may be increased so long as no yellow discharges appear, and no sensible heating of the apparatus takes place. In order to make the apparatus as economical as possible, the air gap used should be long, for then the loss in the steadying resistance is proportionately less, but the over-all pressure is proportionately higher. The authors consider that the observance of the above conditions will materially tend to economy in the commercial application of the electric discharge.

Biological Tests.—A number of tests have been made to prove the sterilizing effect of the gas, and the following are the chief results, as given by Dr. F. M. Blumenthal. The quantity of micro-organisms in 1 gramme was:

Bleached Rye Meal.	Unbleached Rye Meal.	Bleached Wheat Flour.	Unbleached Wheat Flour.
1,600	2,400	170	540

The flour is thus seen to be partially sterilized, and this fact is found to increase very materially the value of the process, since it improves so much the keeping properties of the material treated.

German Practice in Cleaning Blast-Furnace Gases and Coke-Oven Gases.

The fact that American engineers formerly did not pay sufficient attention to the cleaning of blast-furnace gases before delivering them to the gas engines, has undoubtedly been a source of trouble and one of the factors retarding in this country the industrial development of power production from the waste gases of blast furnaces. But it is now generally recognized that purification and simultaneous cooling is an indispensable condition, while the degree of purification required depends on the nature of the ore and also to a certain extent on the type of gas engine used.

In an editorial note on page 291 of our August issue we called attention to the great industrial change which is now taking place in this country in electric power development from blast-furnace gases, mainly due to the activity of the United States Steel Corporation. At this moment it, therefore, seems apropos to review the methods of gas cleaning employed in Germany, as the classical country of this industrial development.

An excellent review of the situation has been given by Mr. K. REINHARDT, of Dortmund, in his Iron and Steel Institute paper, which we have already abstracted on page 355 of our last issue. While this paper covered the whole field of the application of large gas engines in German iron and steel works, we give here that part only which deals with the purification of blast-furnace gases and coke-oven gases.

BLAST-FURNACE GASES.

From what has been learned up to the present time it is clear that a thorough purification and drying of the gas is undoubtedly the principal factor in assuring a continuous and undisturbed working of gas engines. German gas engine manufacturers have from the very first considered the cleaning of the gas an essential condition, while, on the other hand, the Cockerill Co. considered it unnecessary.

As a matter of fact, at many places Cockerill engines were working satisfactorily without any cleaning whatever, while at other works this practice resulted in very disagreeable experiences; in one case, owing to the excessive wear of the working surfaces of the cylinder, and another time owing to premature ignition caused by the formation of a crust, chiefly on the piston ends, favored probably by excessive lubrication.

If at one works the engines gave satisfaction without the gas being cleaned, and at another works similar engines were unsatisfactory, this only proves that the gas, if not cleaned, contains different percentages of dust at various works as it issues from the furnace throat, and that it may become partially cleaned in the gas main. It proves further that the same quantity of dust does not everywhere have the same effect, since it may be composed in some works of soft substances which do not so quickly cause excessive wear of the working surfaces.

The design of the older Cockerill engines was, moreover, as regards the inlet-valves, not very sensitive to the effect of dust, the units most frequently constructed being 600 hp. in one single-acting cylinder, and in consequence the sections of the gas passages before the valve and of the inlet-valve itself were of rather large dimensions, and parts likely to be injured by the dust were not present with the system of governing them employed.

The methods of governing and of mixing the gases in newer constructions, in which more stringent specifications for smaller variations of speed are laid down, are much more sensitive to the presence of dust, owing to their being combined with springs as delicate as possible, in order to keep the resistance of the governor and back pressure upon it as low as possible.

If the spindles or regulating slide valves are covered with a coating of dust, for instance, the springs are no longer sufficiently powerful to move these parts at all, or at the right moment, irregular working results and disturbances in working result. This also occurs if dust is deposited on the valves or slides, the positions of which are regulated by the governor according to the load on the engine. The valves and throttle-valves (manipulated by hand) of the gas main leading to the engine are also very sensitive to dust. The dust deposits on them very readily, and renders them difficult to move, and the areas at these places are for the time being unduly restricted, so that the engine does not receive sufficient gas to maintain its normal power. In all the above cases, in addition to the percentage of dust, the percentage of water contained in the gas when admitted to the engine also exercises an injurious effect.

It is easily understood that moist dust adheres with greater facility to the surfaces with which it comes in contact than dry dust, the greater part of which passes through the engine without being deposited.

Great trouble is experienced with moist and dusty gas when the engine does not run continuously, but stops working on Sundays, for instance. It may then happen that the deposit of wet dust, which, while the engine is continuously working, does not offer very great resistance to the motion of the valve-gear, dries to a hard crust while the engine is not running, and causes these moving parts to become jammed, rendering the starting of the engine impossible.

FIG. I.—ZSCHOCKE SCRUBBER.

The circumstances mentioned above are the result of the gas not being sufficiently purified or dried, as well as of the greater consumption of oil necessitated, and the consequent increase of dirt inside the engine, and, as a matter of fact, are the cause of most of the troubles experienced in working. For this reason in all new plants great importance is attached to the effective cleaning of the gas.

Before the introduction of blast-furnace gas engines the washing of blast-furnace gas was considered necessary or advantageous for blast heating and steam raising purposes; the presence of dust diminished the efficiency of the combustion and of the heat transmission, and rendered frequent cleaning of the hot-blast stoves necessary, although cleaning the gas for the above purposes did not have to be carried out to the degree necessary for the working of engines.

The whole of the gas from the blast furnace is now subjected to a certain amount of washing, determined by experience, while the gas destined for utilization in the engines undergoes still further purification.

For a standard type of purifying plant for blast-furnace gas the following may be observed:

The gases on leaving the blast furnace are led through a series of so-called dry purifiers, and hence through long pipe lines into the coolers or scrubbers, and from these into the so-called centrifugal purifiers. (Theisen apparatus or fans with water spray.) After leaving the above plant the purification of the gas should be complete, so that before being admitted into the engine the gas has only to be dried in filters or in capacious tanks.

In several plants, by drying and by passing through a long main to the engine, a further noteworthy purification of the gas takes place.

With regard to the construction and manner of working of the various apparatus, the following remarks may be made:
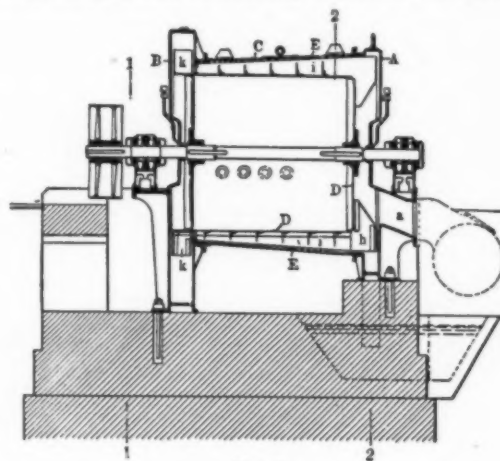
FIG. 2.

THEISEN APPARATUS.

The dry purifiers consist generally of a combination of cylindrical vessels, in which the gas is led downwards with a rapid motion and upwards with a slow motion. During this movement, and especially during the change of direction of the stream of gas, the coarsest particles of dust are separated. The pipes leading from the above should be made as long as possible with as large a section and as many sudden changes of direction as possible, in order that the gas may be further freed from coarse particles of dust.

The coolers or scrubbers are vessels in which the gas flows from the bottom to the top, and the water from the top to the bottom. The water must be finely sprayed in order to moisten the dust, and thereby increase its weight and cause it to settle to the bottom. At the same time the gas is cooled in the
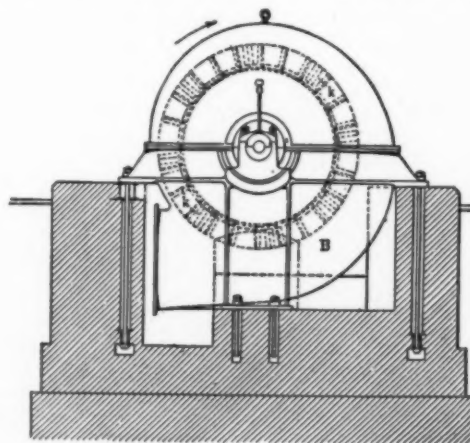
FIG. 3.

THEISEN APPARATUS.

scrubbers, in which the water vapors are condensed, and the dust is deposited.

The vessels are either empty, in which case the water is finely divided by spraying nozzles, or the interior is arranged

with sieves, wire netting, coke or wooden trays, as in the Zschocke scrubber (Fig. 1).

The interior of the Zschocke scrubber consists of a series of wooden trays, one above the other, intended to reduce the velocity of the falling water, and by reason of their special

FIG. 4.
THEISEN APPARATUS.

form to divide the water into fine streams, so that the large surface exposed may effect a satisfactory cooling of the gas. The precipitated dust is removed at the bottom of the scrubber.

In centrifugal purifiers the further separation of the dust is effected by centrifugal action on the wet dust. The application of this apparatus renders it possible to attain a satisfactory purification of blast-furnace gas.
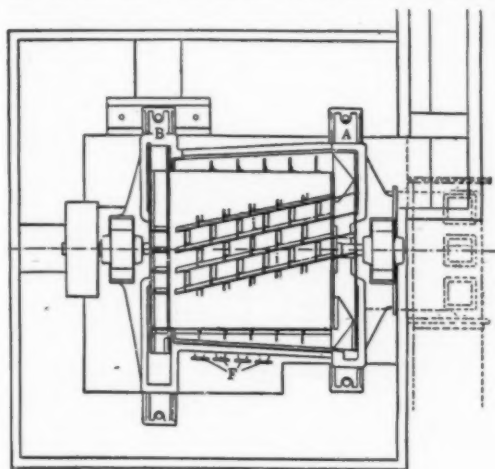
The first centrifugal purifier in Germany was the Theisen apparatus, patented by Mr. Theisen, of Munich. In Duedelingen it was subsequently discovered accidentally that an ordinary fan, with water injection, was also very efficacious for gas cleaning.

The Theisen apparatus (Figs. 2, 3, 4, 5), according to a description given by one of the makers, the Dingler Maschinenfabrik, consists essentially of the following parts: (1) The suction chamber A; (2) the pressure chamber B; (3) the middle chamber C; (4) the drum with shaft and bearings D; (5) the grating E.

Water enters at F tangentially to the casing of the middle chamber C, and leaves the apparatus through the pipe G.

The manner of working this apparatus may be described as follows: After the gas has been cooled and charged with water vapor, it is drawn in by the vanes h, and the coarse dust is separated in the suction chamber. Through the action of the fans at both ends of the drum D the gas is then drawn through the space between the drum and the casing. The outer circumference of the drum (Figs. 2 to 5) is provided with a number of inclined spiral vanes i, so that the gas has also to travel a long way in the form of a spiral. Hence, by injecting water at the same time through the pipes F a high degree of purification of the gas takes place, and the accompanying water vapor is simultaneously condensed. The dust is then projected against the spiral meshes of the coarse grating E fixed to the interior surface of the casing. By centrifugal action the water entering in a tangential direction is at the same time distributed over the surface of the grating, which prevents it from becoming clogged and incrusted with the separated dust. In addition to this, the surface of the water is broken up, thus favoring cooling and condensation. This washing of the gas absorbs carbonic acid and sulphurous gases.

The purified gas then enters the discharge chamber B, from which the water is thrown out by the vanes k, and the gas is forced to the engines with a pressure of from 50 to 100

millimeters of water. The washer reduces the dust from 3 or 4 grammes per cubic meter of gas to 0.02 or 0.03 grammes, with a consumption of 0.8 to 1.5 liters of water per cubic meter. The washer is generally driven by a direct-coupled electromotor, and the smaller sizes by a belting, at a speed of from 300 to 450 r. p. m. The sizes generally used range from 6,000 to 33,000 cubic meters per hour, and the power required from 50 to 150 effective horse-power.

Theisen imputes the useful action, during purification, in his washer to the steam present in the blast-furnace gas and to that formed by contact with the injected water, and on this account recommends his apparatus to be placed, not behind the scrubber, but without such apparatus by introducing simple gas premoisteners immediately behind the dry purifier, in order that the gas may be as hot as possible at the entrance into the apparatus. On the other hand, Prof. Osann, in an exhaustive investigation of the purification of blast-furnace gases, chiefly by the action of cooling surfaces for the water vapors and the deposition of dust, considers it preferable to clean and cool the gases previous to their being introduced into the Theisen washer, so that the latter has only to remove the finer particles of dust which are otherwise difficult to separate. He hopes by this arrangement to effect a saving of power.

The fans employed for the purification of gases, as constructed by R. W. Dinnendahl, at Steele (Fig. 6), only differ from ordinary air fans in the construction of the vanes and bearings, which are of a much heavier construction, to cope with the injection of water and the higher temperature of gas. They are provided with a water inlet at the suction opening, and with an arrangement, as in disintegrators, for pulverizing the water, so that a sort of water curtain is formed through which the dust has to pass. The cohering particles of dust and water are separated by centrifugal action through which these particles are thrown against the inner circumference of the fan casing. The under portion of the fan casing opens into a tank A, from which the separated slimes flow away and the purified gas escapes at the top outlet. The method of purifica-
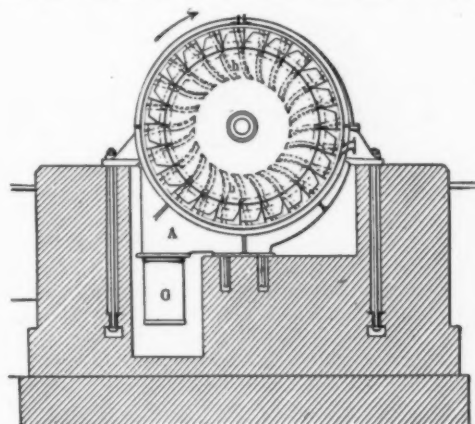
FIG. 5.
THEISEN APPARATUS.

tion resembles that of the Theisen apparatus, except that in the former the passage for the opposing action of the gas and water is not so long.

The usual sizes of gas cleaning fans, according to Dinnendahl, are from 15,000 to 70,000 cubic meters of gas per hour, requiring from 40 to 110 hp. The circumferential velocity of the impellers is up to 56 meters per second, with a diameter of from 1.1 to 1.75 meters. For 1 cubic meter of gas from 1½ to 2 liters of water are required, and the dust is reduced from 3 grammes to 0.2 grammes; as a rule, the percentage of dust is reduced to one-tenth of the percentage before washing.

When two or more fans are arranged parallel to one an-

other for the purification of large quantities of gas, it is often difficult to obtain outputs equal in quantity and quality. It is, therefore, advisable to provide regulating dampers behind the fans, and above all, to make the mains, both before and after the branches to the fans, of large diameter, so that they can at the same time act as air vessels. As a certain preventive of the above difficulties, which are often of a very annoying character, the author can only offer one suggestion, namely, to drive the fans and the electromotors alike with the same speed in such a manner that their axes could be connected with friction couplings, so that the fans produce equal differences of pressure.

Of the other purifying apparatus employed only the Bian cooler may be mentioned. This consists of a horizontal shaft turning within a cylindrical casing and carrying a number of discs of wire netting. The lower halves of the discs dip into water, and the gas passes through the meshes of the upper halves. The purification of the gas is continued in centrifugal apparatus until the desired degree of cleanliness is attained, after which it has only to be dried. This is effected by forcing the gas through a series of layers of wooden fiber or wool in large cylindrical casings, to which it yields its water. Naturally the resistance caused in passing through the layers of wool requires a large expenditure of power, and the renewal of the wet wool, together with the cost of attendance, necessitates
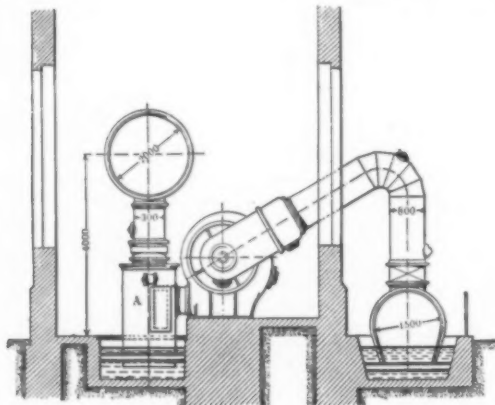

FIG. 6.—DINNENDAHL FAN.

the installation of a spare drier. Large vessels containing various materials through which the stream of gas is forced with frequent changes of direction, are employed for the separation of the water, and these vessels are further aided by long pipes with frequent changes of direction. If a large gas holder is erected between the cleaning plant and the engines, in addition to its quality as a pressure regulator, it does excellent service in the separation of water, and renders the previous drying of the gas and the expenditure for attendance on the plant and the power superfluous.

It must here be mentioned that in several iron works it was not found possible to reduce the percentage of moisture in the gas arriving at the engine to the point of saturation at the corresponding temperature of gas. In such cases, after the supply of water to the scrubbers had been cut off, so that they were only employed as dry coolers and purifiers, the gas has not so perfectly cleaned, but was drier and worked with less harmful results in the gas engines than before.

COKE-OVEN GASES.

A few remarks concerning the purification of coke-oven gas for utilization in gas engines must still be added.

The gas at disposal for this purpose has already been so far purified by the recovery of by-products that, as a rule, only the remains of tar, and also sulphur and cyanides, have to be removed. The tar residues are removed in so-called tar

separators, which consist of high cylinders of boiler plate in which a number of platforms or ledges are arranged alternately to the left and to the right, so that the gases pass through in a zigzag direction and the tar is deposited on the ledges. Other apparatus work in a similar manner, the main stream of gas being divided into a large number of smaller streams and by the resulting sudden alterations of direction, and also by impinging on the plate walls, the gas is freed from tar (Pelouze apparatus). Further, rotary cleaners are in use, which serve for the separation of ammonia, naphthaline, cyanide and sulphuretted hydrogen, and according to the form of the rotating surface are arranged as hurdle, brush or ball washers (patented by Zschocke[1]). The Theisen washer can also serve this purpose; but, as far as the author is aware, it has not as yet been so employed. The inventor hoped to obtain good results, especially in the separation of tar.

The separation of sulphur and cyanide is, according to Prof. Baum, best obtained by filters. The filtering material employed consists of Laming composition, a mixture of bog-iron ore and wood shavings. The composition in layers of 6 to 8 inches deep is carried by plates or gratings; the gas passes through two to four such layers, one after the other, and the iron combines with the sulphur to form iron sulphide, and with the cyanide to make iron cyanides (Prussian blue). The composition is from time to time taken out of the filter and exposed to the air, by which means the sulphur is oxidized and the composition regenerated and ready to be used again.

In passing through the filter not only the sulphur, but also the tarry liquors, water and heavy oils remain behind. For this reason plants which do not require the removal of sulphur often employ filtering apparatus, the Laming composition being replaced by sawdust or wood fiber. Gasometers, which are frequently placed as near as possible to the engines, and as in the case of blast-furnace gas, at the same time regulate the pressure, also serve to dry the gas.

RESULTS OBTAINED IN GERMAN PLANTS.

With reference to the purification and its influence, the following may be seen from the answers received upon a systematic circular inquiry of the Society of German Ironmasters. All smelting works have centrifugal apparatus in use for removing the fine dust, and, indeed, about half of them have scrubbers or Bian coolers and fans, and the rest scrubbers with Thiesen apparatus, Thiesen apparatus alone or fans alone. The respective merits of the various apparatus or processes cannot well be ascertained from the information received from the iron works, as it is not easy to reduce the results to a common basis. The following results, nevertheless, are perhaps of interest:

The power expended in cleaning 1,000 cubic meters of gas per hour varies mostly between 6 and 13 effective horse-power. Accordingly the power expended, in cleaning varies from 1.8 to 4 per cent of the power obtained by the purified gas.

The amount of water used for cleaning varies greatly. It requires on an average from 3 to 8 liters per cubic meter of gas, and is naturally dependent on the temperature of the water. Generally speaking, the water used with centrifugal apparatus alone is less than when it is employed in combination with scrubbers. Similarly the cost of cleaning varies considerably, and includes interest and depreciation of the purifying plant (0.03 to 0.06 pfennig, or 0.0075 to 0.015 cent per cubic meter).

The percentage of dust in the gas after the dry purification, is on an average 4 to 6 grams per cubic meter. In a few cases, however, it is only 1 to 1.5 grams. In most instances the gas for working the engines is reduced to a percentage of 0.015 to 0.03 grams of dust per cubic meter, in a few works even to 0.005 to 0.004 grams per cubic meter.

All these remarks concerning the percentage of dust are to be judged from the point of view that the determination of the

[1] Baum, Glückauf, 1904, No. 17, page 467.

same at one and the same iron works, if not absolutely correct, will always be proportionately exact; but that this latter will perhaps not always be the case of tests carried out by different iron works. It would, therefore, be of importance to adopt a standard method for the determination of the percentages of dust and water, so that all results could be exactly compared.

If the purification effected by the Theisen apparatus is compared with that by fans, it will be found that, according to the manufacturers, the Theisen apparatus cleans in the proportion of 140 : 1. Thus for 1,000 cubic meters of gas cleaned per hour there is required 5 effective horse-power, and per cubic meter 1.15 liters of water on an average.

With a fan the cleaning is on an average 10 : 1, the power required being 2.2 hp. and the water used 1.75 liter.

In order to obtain a similar result, two to three fans would have to be placed one behind the other, which would require perhaps 5 to 6 hp. per 1,000 cubic meters gas per hour, and a consumption of about 4 liters of water per cubic meter of gas.

From the information supplied by the iron works only the total result can in most cases be reviewed; however, in a few cases the result of the cleaning by each apparatus is given, and from this the author concludes that a single Theisen apparatus cleans better than a single fan, since with the former the proportion of cleaning is between 90 : 1 and 25 : 1, with about 6.5 effective horse-power per 1,000 cubic meters gas, and with a fan the proportion is about 12 : 1 and the average effective horse-power 2.3. From two fans, one placed behind the other, a proportion of cleaning from 50 : 1 to 200 : 1 and power employed from 6.5 to 10 effective horse-power per 1,000 cubic meters per hour has been attained. Without taking the consumption of water into consideration one Theisen apparatus is approximately equal to two fans.

With one exception, all iron works possess apparatus for drying the gas as described above.

In no case does the gas contain any suspended water—that is, no water above the quantity at the point of saturation at the corresponding temperature.

This temperature is in most cases the same as the temperature of the air, or only a few degrees higher. In a few cases the percentage of water is even lower than that corresponding to the point of saturation at the temperature of the gas, but this is only possible when the water used for cooling is at a very low temperature, and the gas is cooled to below the temperature of the gas arriving at the end of the gas main.

A further cooling of the gas would be of great utility, favoring the separation of water and purification, and thereby assuring the continual working of the gas engines without disturbance.

The particulars which the author received from the collieries are not so complete as those received from iron works, owing to the collieries not yet having so much experience.

Of fifteen collieries which were questioned, two had no special plant for the purification of gas, but only plant for the recovery of the by-products; four collieries have plant for the separation of sulphur and tar; six a similar plant for sulphur only, and three a plant for tar only. The power expended is only that necessary to overcome the resistance of the gas passing through the purifier, which is on an average about 1/4 per cent of the power developed. The other working expenses consist only of the renewals of the filtering material, which amounts on an average to about 0.03 pfennig (0.0075 cent) per cubic meter, whilst the expenses of the purification plant itself increases greatly with the sulphur in the gas.

Only traces of tar have to be removed by the purifier, but it is much more important to remove the sulphur, which attacks the cylinders, piston rings, piston rods and stuffing boxes.

In one case it is stated that the percentage of sulphur was reduced from 5 grams to 0.7 grams per cubic meter.

The heating value of coke-oven gas varies from 2,500 to 4,600 calories per cubic meter.

The amount of gas available for gas engines also varies extraordinarily, ranging from 3¼ to 50 per cent, according to the quality of the coal used, and above all according to the type of coke oven.

In the replies to the questions addressed to iron works, attention should be called to the fact that about one-half of the works place gas holders between the purifying plant and the engines. The capacity of the holders in proportion to the gas consumption varies considerably. One iron works places a gas holder of smaller size, arranged as an equalizer of pressure, before each engine.

The pressure of the gas at the engines is on an average from 2 to 4 inches, but in many plants it is 8 inches and over. The variations in the gas pressure naturally depend on the number of gas engines at work and of furnaces in blast, and on whether the blast-furnace tops are provided with a double seal or not. As a rule, it is recommended that the gas pressure be maintained as regularly as possible, and not much above the pressure of the atmosphere (about equal to from 1¼ to 2½ inches water). This can, of course, only be done by using a gas holder, which, besides being an excellent separator for water, possesses the advantage of preventing a reduction of speed or even the stopping of the gas engines when the supply of gas is suddenly interrupted for a short period, as may happen when only a small number of blast furnaces are at work. Long gas mains of large section also serve as a reserve, although not so effectively, and for a short period tend to equalize the pressure.

The intervals at which the engine or its several parts have to be cleaned vary greatly. From information received from iron works, it may be concluded that with gas well cleaned (0.015 to 0.3 grams of dust per cubic meter), and at the same time well cooled and dried, the inlet gear—that is, the parts before the cylinder of the engines—must be cleaned at intervals of two to three months, and a complete internal cleaning must be undertaken every six or eight months.

In a few plants using gas which is specially clean, the engines require less frequent cleaning. In others the inlet-gear, throttle valves and other similar parts require cleaning at periods of fourteen days. At the same time, when the lubrication is not excessive, and even when the gas is not well cleaned, an internal cleaning of the engine every two or three months is sufficient.

The parts before the cylinder require for cleaning on an average from 6 to 20 hours, according to the size and build of the engine and the number of men employed, and the internal cleaning requires from two to eight days.

The quantity of water used for cooling the cylinders and pistons averages 8.8 to 11 gallons per hour and per effective horse-power, of which 2.2 to 2.6 gallons are for the pistons. The consumption of oil in most plants is reckoned at 1 to 1.25 grammes per hour per effective horse-power. The consumption of gas has not yet been sufficiently tested to compare the various systems.

According to trials made at iron works, the heat employed by the engines varies from 2,200 to 3,300 calories per hour and per effective horse-power. Most iron works are at present not yet in a position to determine the consumption of gas in their engines, and content themselves with testing the exhaust gases, and thereby determining the completeness of the combustion in the motor.

From the answers received from the collieries, engines using coke-oven gas require cleaning after similar periods to those using blast-furnace gas.

Generally speaking, however, at present the collieries have not sufficient experience to answer this and other questions authoritatively. The traces of tar in coke-oven gas, which are difficult to remove and to burn, probably necessitate more frequent internal cleaning; and above all, the piston rings, stuffing boxes, oil holes and other similar parts require greater attention.

Electro=Decolorization—A Study in Optical Sugar Analysis.

By F. G. Wiechmann, Ph. D.

The Problem: Saccharimeters are designed to return a reading of 100° Ventzke, representing 100 per cent of sucrose when the chosen normal weight of chemically pure sucrose is dissolved in the chosen volume of water.

The ideal clarifying reagent would be one which would remove from a normal aqueous solution of raw sugar everything except the sucrose and the water, and which in so doing would cause no change whatever in the original optical rotatory power of the sucrose.

It is well known and generally admitted that the basic acetate of lead solution as at present used—with the sanction of the International Commission for Uniform Methods of Sugar Analysis—for the clarification of sugar solutions, is not above criticism.

In the first place, the use of this reagent causes an error by its mere presence: the precipitate it forms in clarifying the sugar solution occupies a part of the space which should be taken up by the solution, and in consequence, that solution is unavoidably concentrated.

In the second place, this reagent forms chemical combinations with at least some of the optically active bodies which are frequently present in raw sugars without, however, necessarily removing such bodies from the solution. It is a well known fact that such chemical combinations formed by this reagent with these optically active bodies, sugars and non-sugars, possess optical properties different from those originally exhibited by the bodies, and that it is, therefore, practically impossible to make a proper allowance for their optical influence.

Seeking for a method by which the difficulties indicated might be at least partially avoided or overcome, attention was naturally turned to electrical energy as the agent capable of bringing about chemical changes without necessarily introducing material reagents into the solution under examination. Making this consideration the point of departure, several series of experiments were planned to determine what degree of decolorization might be secured in sugar solutions by passing electric currents through them respectively from insoluble and from soluble electrodes.

Four experimental series were thus made:

Series A—Electrodes, platinum; solvent, water.
Series B—Electrodes, platinum; solvent, water and hydrogen peroxide solution.
Series C—Electrodes, lead; solvent, water.
Series D—Electrodes, anode, lead-peroxide; cathode, lead; solvent, water.

In all instances the work was done on *normal* sugar solutions, that is to say, on sugar solutions made up to the proper degree of concentration *before* decolorization, and in each of these methods, therefore, if feasible, the precipitate error would be entirely obviated.

Source of Current: The electrical energy used in these experiments was secured either from a motor generator, or from the direct lighting current available in the laboratory.

The motor generator was a low-voltage (electrolytic) generator with a range of from 3 to 15 volts, run by a motor on a 110-volt direct current.

When the lighting current was used directly the current density was regulated by means of a bank of electric lamps made by arranging a number of lamp sockets partly in parallel, partly in series, upon a slab of slate, and inserting the necessary number of lamps properly grouped to give the desired result.

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* Abstract of an address given before the International Commission for Uniform Methods of Sugar Analysis at Berne, Switzerland, Aug. 3, 1906

Current Measurement was effected by means of a Weston voltmeter and a Weston milli-volt meter, used as an ampere-meter.

The voltage was measured directly across the electrodes, the ammeter was inserted in the main circuit.

Electrodes: As previously stated, both insoluble and soluble electrodes were used in the experiments. Carbon and platinum were tried as representative of the first group; aluminium, lead and lead-peroxide were used in the tests with soluble electrodes.

Various forms of electrodes were experimented with: foils, flags, annular rings and bands, open and closed cylinders, wave plates and wires.

In some experiments both electrodes were stationary, in others, one of the electrodes was kept in motion. In short, a great many preliminary experiments were made in order to ascertain the current normal density $N D_{100}$; i. e., the current strength for 100 square cm. of electrode surface, best suited for the work to be done.

At first a number of tests were carried out in which both electrodes were placed in one compartment; later it was determined to be distinctly preferable to work with the two electrodes in separate compartments.

This naturally brought the problem of septa up for consideration.

Septa: A number of experiments were made with septa of clay and of porous earthenware, but finally parchment was selected as best adapted to the needs of the situation.

Experience taught that considerable caution has to be exercised in the selection of the parchment for the purpose. Some of the parchment first experimented with diffused an optically active, copper-reducing body into the solution, and, of course, vitiated the experiment.

It was soon learned that all of such parchment-sugar can be entirely removed by repeated boiling with distilled water, and all of the experiments to be described hereafter were made with parchment thus treated and subsequently dried and ironed to perfect smoothness. Each batch of parchment so prepared for experimental work was, of course, submitted to preliminary examination, both optical and with Fehling's solution, to ensure the removal of every trace of the parchment-sugar.

Electro-Cells: Two forms of cell were adopted; one, cylindrical in form, consists of a cell frame of hard rubber, designed to support a cylinder of parchment. This cell is placed within a cell or beaker of glass. The one electrode, a cylinder with closed ends, is placed within the parchment cell; the other electrode, an annular band, is fitted tightly against the wall of the glass cell.

The whole apparatus can be enclosed in a water jacket, through which a current of water can be kept coursing during the experiment, should an absolutely uniform temperature of the cell contents be maintained.

The distance between each electrode and the parchment is 5 mm. A platinum wire from each electrode is connected with the copper leads which supplied the current. Experiments were made with this circular cell in which the $N D_{100}$ values ranged from 1.11 to 4.92.

The square cell is also made of hard rubber. It consists of two plates, each 125 mm. square, and rimmed on three sides with raised edges 12 mm. thick. The receiving chambers, which have been hollowed out of the rubber plates to a depth of 5 mm., are 100 mm. x 110 mm., and are each provided at the base with a discharge opening.

To use the apparatus the parchment septum is placed between these two rubber plates, these are tightly locked together by four pegs placed at the corners, and the whole is then firmly clamped in a wooden frame; after the two electrodes have been slipped into place on either side of the parchment the apparatus is ready for use.

The distance from each electrode to the septum is 5 mm. The electrodes have each an active surface of 100 square cm.,

and the amperes employed, therefore, at once express normal current density values.

OPTICAL DETERMINATIONS: All of the polarimetric observations were made by means of a double-wedge compensation saccharimeter built by J. Peters, of Berlin, examined and certified to as correct by Prof. Dr. Herzfeld, of the Institute of Sugar Industry at Berlin.

The correct adjustment of this instrument was controlled before each experiment by means of a standard quartz plate and by observations of the zero point. Furthermore, the observation-tube which was used in each instance was examined as to any possible optical activity of its cover glasses before being filled with the solution to be examined. The light was in every instance obtained from a 50-candle power, 110-volt, spiral-shaped filament, and the light so obtained was passed through 3 centimeters of a 6 per cent solution of potassium dichromate; the temperature of the saccharimeter was held as close to 20° C. as possible. Naturally, only carefully standardized metric flasks and weights were used. The solution in each case was made up by dissolving 26 grams of the sugar to a volume of 100 metric C.C.

TINTOMETER OBSERVATIONS: The amount of decolorization secured was determined by means of a Lovibond tintometer. A description of Lovibond's method will be found in the *Journal of the Society of Chemical Industry*, Vol. XIII., No. 4, April 30, 1894.

The method adopted to determine the amount of color removed consisted in matching the color of both the original solution and of the treated solution against the Lovibond glasses, subtracting the value representing the treated solution from that representing the untreated solution, and calculating the percentage of color removed.

RECORD OF EXPERIMENTS: As an illustration of the manner in which the experimental work was done the record of a single experiment is here given:

Number of solutions prepared = two, A and B.
Sugar used, first beet sugar.
Solvent used, water.
26.0 grams up to 100 metric C.C.
Solution A, clarified with 2 C.C. basic lead acetate solution. Int. Com. Standard.
Room temperature = 20° C.
Solution temperature = 20° C.
Saccharimeter temperature = 20° C.
Saccharimeter in adjustment at zero point and at 98.6°.
Polarization readings in 200-mm. tube.

Observers:	A	B
	94.7	94.8
	94.7	94.7
	94.7	94.6
	284.1	284.1
	94.7	94.7

Average polarization = 94.70.

Solution B—No preliminary clarification; solution placed in electro-cell; current passed for 5 minutes.

Electrodes:
Anode   = lead 10 x 10 c.m.
Cathode = lead 10 x 10 c.m.

Temperature data:
Original solution, before passing electric current, 20.0° C.
Anode solution, after passing electric current, 20.0° C.
Cathode solution, after passing electric current, 20.0° C.

Reaction:
Original solution—acid to litmus.
Anode solution—acid to litmus.
Cathode solution— { alkaline to litmus.
{ alkaline to phenol-phthalein.

Distance between electrode and parchment in each chamber = 5 mm.

Electric Data.		Ampere.	Volts.
Start.		0.25	4.0
After 30 seconds.		0.26	4.0
" 60 "		0.27	4.3
" 90 "		0.26	4.2
" 120 "		0.24	4.2
" 150 "		0.24	4.6
" 180 "		0.23	4.75
" 210 "		0.21	4.65
" 240 "		0.20	4.75
" 270 "		0.20	4.75
" 300 "		0.20	4.80
Average N D$_{300}$ =		0.23	4.45

Decolorization:

			Per Cent of Color Removed.
Original solution = Glass 24			....
Anode solution = " 3			87.50
Cathode solution = " 18			25.00

Polarization readings of anode solution in 200-mm. tube.
Saccharimeter in adjustment at zero and at 98.6°.
200-mm. tube, empty, optically inactive.
Room temperature 20.0° C.
Solution temperature 20.0° C.
Saccharimeter temperature 20.0° C.

Observers:	A	B
	94.60	94.80
	94.90	94.85
	94.80	94.80
	284.30	284.45
	94.77	94.82
	94.77	
	94.82	

Average polarization = 189.59 ÷ 2 = 94.79.
Polarization of solution, clarified with basic acetate of lead 94.70
Polarization of anode solution after electric treatment.   94.79

Difference = 0.09

EXPERIMENTAL DATA: As previously stated four experimental series were carried on, A, B, C and D.

The results obtained in series A and B were not satisfactory.

SERIES C: In Series C both electrodes were made of sheet lead and no hydrogen peroxide or any other reagent was used. The following data were obtained:

Experiment No.	Sugar Used.	N. D.$_{100}$	Anode Solution Percentage of Color Removed.	Polarization Determined in a Tube of:
6	Sand. Island I........	.25	86.84	200 mm.
28	" "	.25	94.83	200 "
29	" "	.16	93.10	200 "
30	" "	.13	87.93	100 "
4	" " II........	.25	94.12	200 "
25	Matanzas Centrifugal..	.25	93.58	200 "
26	Porto Rico Muscovado	.25	85.29	100 "
24	Java Centrifugal......	.17	96.15	200 "
14	Beet I..............	.25	87.50	200 "
12	"	.25	91.94	200 "
27	"	.25	91.37	200 "
31	"	.33	93.54	200 "
20	"	.24	88.24	200 "
32	"	.25	85.18	200 "
21	"	.26	88.10	200 "
33	"	.23	87.50	200 "
18	" II.............	.26	90.50	200 "
80	Sand. Island II.......	.25	95.10	200 "
90	" " I........	.41	92.10	200 "

A glance at these results shows that the decolorization obtained was very satisfactory; considering all of the twenty experiments recorded on raw sugars of various origin and grades an average decolorization of 90.56 per cent was attained.

SERIES D: In oxidation processes the energy with which the reaction proceeds at the anode is determined by the anode potential. Frequently the oxidation of certain substances can thus be effected by a peroxidized anode that cannot be secured by a purely metallic anode having a lower potential pressure, and it was, therefore, determined to try some experiments in which the cathode should be of lead, but in which the anode of lead should receive a coating of lead peroxide, to learn whether possibly a still more efficient decolorization might be secured.

The peroxide plate was prepared in the following manner: Three lead plates were thoroughly scoured with sand and water, then placed into a hot and fairly concentrated solution of caustic soda, and then after remaining therein for a few minutes were thoroughly rinsed with clean water.

These three plates were then hung as electrodes into a 20 per cent solution of sulphuric acid, the central plate was made the anode and the other two were linked as cathodes. An electric current, $N D_{100} = 2.0$ amperes. voltage = 2.5 volts, was then passed for 30 minutes. Should it be desired to coat only one side of the lead plates with the lead peroxide, then two such plates can be prepared in one operation by making those two plates the anodes, and the central plate the cathode in the above sketched arrangement.

When peroxidized the plate is washed thoroughly with water, then placed for 3 or 4 minutes in boiling water, thoroughly rinsed with alcohol and finally dried.

The data found in this set are given in the list appended:

Experiment No.	Sugar Used.	$N.D._{100}$	Anode Solution Percentage of Color Removed.	Polarization Determined in a Tube of:
42	Beet I...............	.25	94.00	200 mm.
43	Sand. Island I........	.25	96.40	200 "
44	" " II........	.22	94.44	100 "
45	" " III......	.24	46.36	Not readable.
46	Matanzas Centrifugal..	.22	86.11	100 mm.
47	Sand. Island I........	.24	96.00	200 "
48	Porto Rico Muscovado	.23	86.68	100 "
49	Java Centrifugal.......	.12	97.50	200 "

With few exceptions the decolorizations obtained compare favorably with the results secured in Series C, yet, the additional work necessary to prepare peroxidized electrodes appears to outweigh, or more than outweigh the slight advantage gained.

Of the four experimental series tried it would thus seem that Series C is the most simple and effective. The following table contains the polarization values found in this series, and also the polarization values obtained on the same sugars after clarification with a minimum amount of basic lead acetate solution:

Experiment No.	Sugar Used.	Polarization by Lead Acetate Solution-Method.	Electro-Method.	Result by Electro-Method is +
6	Sand. Island I........	97.15	97.66	+ .51
28	" "	97.29	97.60	+ .31
29	" "	97.29	97.43	+ .14
30	" "	97.29	97.58	+ .29
4	" " II.......	90.40	90.37	+ .03
25	Matanzas Centrifugal..	92.79	93.00	+ .21
26	Porto Rico Muscovado	90.81	91.05	+ .24
24	Java Centrifugal.......	97.77 *	98.00	+ .23
14	Beet I...............	94.23	94.40	+ .17
12	"	95.69	96.23	+ .54
27	"	95.86	96.32	+ .46
31	"	96.15	96.39	+ .24
20	"	93.72	94.15	+ .43
32	"	93.75	94.17	+ .42
21	"	94.75	95.20	+ .45
33	"	94.47	94.79	+ .32
18	" II*............	91.60	91.69	+ .09

* (Current on 10 minutes.)

Attention is invited to the last column of this table, which shows the difference between the polarization values found by the two methods.

While it were idle to expect perfect agreement in duplicate analyses made by one, let alone made by two methods, yet it is peculiar that the results of the one method should in every instance be higher than the results of the other.

Careful experimental study showed that this discrepancy was not caused by kataphoresis nor by a concentration of the solution—due to evaporation or electrolytic decomposition of the solvent; furthermore, it was experimentally determined that the optical value of the sucrose and of the invert sugar were not directly affected by the electric currents used.

The question, however, whether the rotary power of some other optically active constituents in the sugar solution was altered by the process had still to be settled.

In all of the experiments made record was kept of the chemical reaction of the solutions before and after the passing of the electric current, and it was found that in every instance the anode solution—the solution used for polarization after the electric treatment—reacted acid, whatever the reaction of the original solution might have been.

Now, it is well known that some organic non-sugars which are optically active, experience a change, in some cases even an absolute reversal of their optical rotation value according to the reaction of their solutions, acid or alkaline.

Asparagine and some of its derivatives, for instance, act in this way. Asparagine, which when decomposed yields ammonia and aspartic acid, exhibits levo-rotation in aqueous solutions, an increased levo-rotation in alkaline, but a dextro-rotation in acid solutions.[1]

The high polarizations observed might hence have been caused by this substance; a probable indication of its presence was the strong ammoniacal odor noticeable in several instances in the cathode solutions during the electro-treatment, and the marked deepening of the color of these cathode solutions.

Asparagine is present in beets to the extent of possibly 0.1 to 0.2 per cent, it also occurs in cane products. To settle the question whether asparagine was the cause of the discrepancy or not, Champion and Pellet's method[2] was tried.

After electro-treatment and after a subsequent polarization of the anode solution, 10 per cent of an 8 per cent aqueous solution of acetic acid were added to the anode solution and the same re-polarized.

In case asparagine or one of its derivatives should prove to be the cause of the increased polarization, lower values were to be expected after the use of the acetic acid.

The following table embodies the results obtained:

Experiment No.	Sugar.	Polarization Determined by: Basic Lead Acetate Solution.	Electro-Method.	Electro-Method + 10% Acetic Acid Solution.
1	I Beet...............	95.70	96.58	95.63
2	Java Centrifugal......	97.60	98.00	97.64
3	" "	97.60	98.17	97.57
4	Matanzas Centrifugal..	92.59	93.14	92.55
5	Porto Rico Muscovado	90.66	90.87	90.61
6	Sand. Island I........	97.21	97.56	97.13
7	" " II.......	90.48	.....	90.46

From this table it appears that the differences between the results of the polarizations obtained by clarification with basic lead acetate solution and by the electro-method. after the use of acetic acid, are practically identical, the difference on an average being less than 0.05° Ventzke.

The practical working of the electro-method for decolorizing sugar solutions may hence be summarized as follows:

Dissolve 26,000 grams of sugar with pure water up to a

[1] A. Rümpler, Die Nichtzuckerstoffe der Rüben, 1898, pages 270, 271.
[2] Compt. Rend., 1876, Vol. 82, page 819. Zeitschrift d. Vereins f. d. Rübenzucker-Industrie, 1876, Vol. 26, page 819.

volume of 100 metric cubic centimeters, at a temperature of 20° Centigrade.

Place about 35 C.C. of this solution into each of the two chambers of the electro-cell previously described, and pass an electric current of approximately $N\ D_{100} = 0.25$ through the solution for 5 minutes.

Discharge the solutions separately. Filter the anode solution perfectly clear into a graduated receiver, add to this solution 10 per cent of its volume of an 8 per cent acetic acid solution, and polarize. To the reading observed on the saccharimeter add 10 per cent to compensate for the dilution caused by the addition of the acetic acid solution; the result is the polarization sought.

In these experiments lead electrodes have been used. On theoretical grounds possibly insoluble electrodes might be preferable, and additional experiments are now in progress in the writer's laboratory in which platinum electrodes and platinum electrodes coated with platinum black are used in their stead.

The amount of lead which passes into the solution in these experiments is, however, trifling, on an average only 7.14 per cent of the amount used in the clarification by the basic lead acetate solution.

In the electro-method, of course, the precipitate error is entirely obviated, as the lead enters the solution only after the same has been made up to its proper volume, and in this respect, at least, the method entirely fulfills the purpose for which it was devised.

Gaseous Fuels.

By Oskar Nagel, Ph. D.

The gaseous fuels have, like the liquid fuels, the advantages of burning up without residue, of easy transportation to the place of combustion, and of convenient regulation of temperature. Furthermore, the length of the flame can be varied within certain limits, and for complete combustion a considerably smaller excess of air is required than with solid and liquid fuels. The gaseous fuels, therefore, have a higher temperature of combustion, and generate a smaller quantity of gaseous products of combustion than other fuels of same composition, whereby a better utilization of the generated heat can be accomplished. Another advantage is that in this case not only the air for combustion but also the gas can be preheated.

Such gaseous fuel occurs in nature and is then called natural gas. The average composition of natural gas of Pennsylvania is:

Methane	67%
Hydrogen	22
Nitrogen	3
Ethane	5
Ethylene	1
Carbon dioxide	0.6
Carbon monoxide	0.6

As the occurrence of natural gas is limited, similar gases are artificially produced for industrial use by the following methods:

1. Dry distillation of substances containing carbon, as coal, ignite, peat, wood, fat, etc., whereby gases of distillation (illuminating gas) are obtained. According to the raw material used the manufactured gas is called coal gas, peat gas, wood gas, fat gas, oil gas, etc.

2. Incomplete combustion of coal with insufficient amount of air, whereby generator gas, also called producer gas or air gas, is obtained.

3. Decomposition of water (steam) by glowing coal or combustion of coal by means of steam, whereby water gas is obtained.

In special cases other methods are used for producing fuel gases, as for instance:

4. Incomplete combustion of coal by simultaneous action of air and oxides, the latter thereby being reduced. This reaction takes place in iron blast furnaces and furnishes a gas of high fuel value, low in nitrogen and high in carbon monoxide, which is called blast-furnace gas. If water is used as oxide, semi-water gas or Dowson gas is obtained.

5. For getting high temperatures or high luminant power, acetylene C_2H_2 is sometimes used, which is obtained by reaction of calcium carbide and water:

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$$
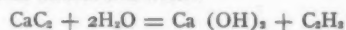
We, therefore, have the following summary of methods for the

Production of Fuel Gases.

1. By dry distillation:
   From coal, coal gas.
   From peat. peat gas.
   From wood, wood gas.
   From fat, fat gas.
   From oil residue, oil gas.

2. By incomplete combustion of coal:
   (a) With air alone, producer gas (air gas).
   (b) With air and oxides of metals Fe_2O_3, etc., blast-furnace gas.
   (c) Air and steam, Dowson gas.
   (d) Air and carbon dioxide, regenerated combustion gases.

3. By decomposing carbides with water:
   Mainly calcium carbide, acetylene.

Leaving aside the acetylene and the blast-furnace gas, which is only of local importance, the following industrial gases have to be mainly considered:

(1) Gases of distillation, obtained by dry distillation of carbonaceous substances.

(a) Illuminating gas made in retorts. It is used for illuminating, heating and for internal combustion engines.

As an example, the composition of French illuminating gas is given below, which is identical all over France:

Weight of cubic meter = 0.523 kg.
Thermal value of 1 cubic meter = 5600 Ca.
Weight of 22.42 liters = 2 grams.
Thermal value of 2 grams = 125 Cal.

Analysis in per cent by weight:
Carbon, 43.2 per cent.
Hydrogen, 21.3 per cent.
Oxygen and nitrogen, 25.5 per cent.

Analysis in per cent by volume:

51.0%	H_2
33.0	CH_4
8.8	CO
1.8	CO_2
1.0	$O_2 + N_2$
1.1	C_2H_6
3.3	absorbable CnH_2n
100.0	

(b) Gases of distillation, produced as by-product in the coking or charing of fuels, mainly coke-oven gas.

(2) Generator gas, air gas, or producer gas, is properly the name of such gas only, which is made from carbon (charcoal or coke); i. e., from a coal free from hydrogen and oxygen and using dry air for the incomplete combustion. In practice, however, we comprise under the classification "generator gas" any gas generated in certain apparatus (gas producers) by leading air without steam through a glowing layer of fuel of sufficient height. The air never being dry, we get in practice always a mixture of generator gas and water gas, and also gases of distillation if crude, uncoked fuel is used.

(3) Water gas is used for illuminating and fuel purposes.

(4) Semi-water gas or Dowson gas is used for fuel and power purposes, and is prepared by leading a mixture of air and steam through a coal layer in a producer.

GENERATOR GAS OR PRODUCER GAS.

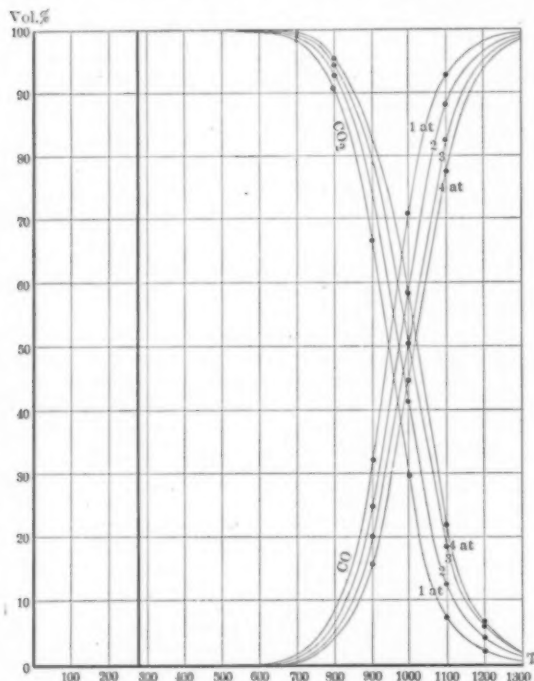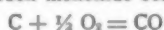If air is led at moderate speed through a layer of pure carbon (in practice charcoal or coke), incomplete combustion

FIG. I.—IDEAL COMPOSITION OF GENERATOR GAS FROM PURE OXYGEN.

takes place; *i. e.*, by the reaction of oxygen on the glowing coal, formation of carbon monoxide occurs:

$$C + \tfrac{1}{2}\,O_2 = CO$$

Supposing the air to contain 4 mols nitrogen to 1 mol oxygen, which is probably correct, we can write the reaction:

$$C + \tfrac{1}{2}\,O_2 + 2N_2 = CO + 2N_2$$
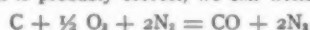
and we get a gas which theoretically contains 2 mols N_2 to 1 mol CO, and should have the composition:

CO 33.3% by volume
N 66.7 " "

This gas ought to yield per 22.42 liters if burned at constant volume $0.333 \times 67.9 = 22.61$ Cal. If burned at constant pressure $22.61 + 0.5 \times 0.54 = 22.88$ Cal. The thermal value of the same at constant pressure would be per cubic meter 1020.5 Cal.

The thermal value of 1 gram of gas is calculated as follows: According to the equation the gas has for every gram-matom of carbon

12 grams carbon ⎫
16 grams oxygen ⎬ 28 grams carbon monoxide.
56 grams nitrogen. ⎭

Sum: 84 grams.

As 84 grams of gas contain 3 mols (CO plus $2N_2$), 22.42 liters of the same at 0° C. and 760 mm. are equal to 28 grams, and, therefore, 1 gram of gas generates 817 Cal.

This reaction, however, only takes place at very high temperatures. At lower temperatures a second reaction occurs simultaneously, and the extent to which it occurs increases with decreasing temperature. This reaction is

$$C + O_2 = CO_2$$
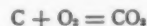
or if the air is used instead of oxygen

$$C + O_2 + 4N_2 = CO_2 + 4N_2$$
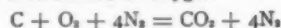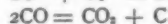
Between these two reactions there exists a certain equilibrium for every temperature and pressure. If we subtract the equation

$$C \quad + O_2 \ = CO_2$$
from $\quad 2C \ + O_2 \ = 2CO$
we get $\quad 2CO = CO_2 + C$
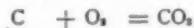
which reaction actually takes place at fairly high temperatures and determines the proportion of the two first reactions. It is reversible:

$$2CO \rightleftarrows CO_2 + C$$

That is, while pure CO within certain temperatures is decomposed into CO_2 and C, we find that under similar conditions CO is produced by reduction of CO_2 by means of C. Therefore, there exists necessarily an equilibrium between CO, CO_2 and C, which depends on the temperature and concentration (gas pressure).

Since out of two volumes CO only one volume CO_2 is formed, and since the reaction, according to our equation (from left to right), takes place without decrease of volume, it is clear that an increase of pressure facilitates the formation of CO_2, while a decrease of pressure favors the formation of CO. Therefore, the primary air (wind) in a gas pro-
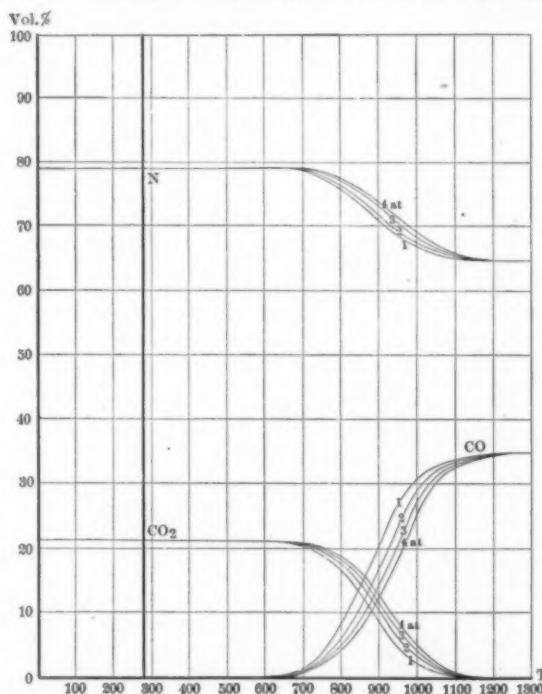
FIG. 2.—IDEAL COMPOSITION OF GENERATOR GAS FROM DRY AIR.

ducer should be of low pressure if a gas high in CO is desired.

The influence of temperature on the equilibrium is shown by the balance of the reaction heats:

$$C \quad + O_2 \ = CO_2 \ + 94,310 \text{ Cal.}$$
$$2(C + O) = 2CO \ + 53,400 \text{ "}$$
$$\overline{}$$
$$2CO = CO_2 + C \ + 40,910 \text{ "}$$
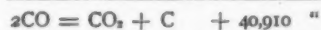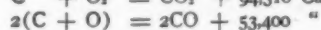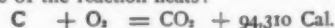
i. e., the decomposition of 2CO into CO_2 and C takes place under generation of heat. Therefore an increase of temperature facilitates the formation, a decrease of temperature the decomposition of CO. Thence it is clear that the gas will be the richer on CO with higher temperature.

TABLE A.
IDEAL COMPOSITION OF PRODUCER GAS (GENERATOR GAS) PRODUCED WITH PURE OXYGEN.

Air Pressure. Volumetric Composition at a Temperature of		1 Atmosphere.		2 Atmosphere.		3 Atmosphere.		4 Atmosphere.	
		CO	CO_2	CO	CO_2	CO	CO_2	CO	CO_2
227° C	500° abs.	0.004	99.996	0.0028	99.9972	0.0023	99.9977	0.002	99.998
327°	600°	0.123	99.877	0.087	99.913	0.0711	99.9289	0.061	99.939
427°	700°	1.427	98.573	1.011	98.989	0.826	99.174	0.716	99.284
527°	800°	8.794	91.206	6.303	93.697	5.177	94.823	4.499	95.591
627°	900°	32.542	67.458	24.809	79.191	20.408	79.592	17.945	82.055
727°	1000°	70.35	29.65	58.105	42.259	51.788	48.212	47.017	52.983
827°	1100°	92.75	7.25	87.198	12.802	82.72	17.28	78.987	21.013
927°	1200°	98.445	1.555	97.00	3.00	95.65	4.35	94.315	5.685
1027°	1300°	99.50	0.50	99.00	1.00	98.97	1.03	98.67	1.33

All these observations are of importance for the state of equilibrium. Whether this is reached in practice or not depends on the height of the coal, porosity of same, velocity of wind, etc. It is, however, of the greatest importance for the theory of the gas producers as well as for the practice, to know the equilibrium for all the different conditions, since the only way to judge the quality of a gas producer process is to compare the results obtained in practice with those corresponding to the theoretical equilibrium.

We, therefore, give in Tables A, B and C the ideal composition of generator gas at different temperatures and pressures.

Table A gives the ideal composition of producer gas, produced with pure oxygen. Fig. 1 shows the content of this table graphically.

Table B gives the ideal composition of producer gas, produced with dry atmospheric air. The data of this table are graphically shown in Fig. 2.

TABLE B.
IDEAL COMPOSITION OF PRODUCER GAS (GENERATOR GAS) PRODUCED WITH DRY ATMOSPHERIC AIR.

Gasifying Temperature. °C	T° abs.	Partial Pressure of CO+CO2 in atm.	Composition in Per Cent. by Volume. CO_2.	CO.	N_2.
Air Pressure — 1 Atmosphere.					
227°	500°	0.21	21.00	.....	79.00
327°	600°	0.21	21.00	.....	79.00
427°	700°	0.2145	20.31	1.14	78.55
527°	800°	0.24	16.40	7.60	76.00
627°	900°	0.29	8.75	20.25	71.00
727°	1000°	0.334	2.14	31.26	66.60
827°	1100°	0.344	0.47	33.93	65.60
927°	1200°	0.346	0.14	34.46	65.40
1027°	1300°	0.3465	0.01	34.65	65.35
Air Pressure — 2 Atmospheres.					
227°	500°	0.42	21.00	.....	79.00
327°	600°	0.42	21.00	.....	79.00
427°	700°	0.4228	20.39	1.01	78.60
527°	800°	0.466	18.14	5.82	76.70
627°	900°	0.555	11.94	17.09	72.25
727°	1000°	0.6535	4.31	29.56	67.32
827°	1100°	0.6865	0.83	33.74	65.67
927°	1200°	0.692	0.21	34.44	65.40
1027°	1300°	0.693	0.10	34.56	65.35
Air Pressure — 3 Atmospheres.					
227°	500°	0.63	21.00	.....	79.00
327°	600°	0.63	21.00	.....	79.00
427°	700°	0.6395	20.51	0.81	78.68
527°	800°	0.686	18.14	4.76	77.00
627°	900°	0.8075	11.94	14.98	73.08
727°	1000°	0.957	4.31	27.59	68.10
827°	1100°	1.625	0.83	33.37	65.80
927°	1200°	1.0365	0.21	34.34	65.45
1027°	1300°	1.04	0.10	34.56	65.34
Air Pressure — 4 Atmospheres.					
227°	500°	0.84	21.00	.....	79.00
327°	600°	0.84	21.00	.....	79.00
427°	700°	0.851	20.59	0.71	78.70
527°	800°	0.905	18.52	4.11	77.37
627°	900°	1.056	12.73	13.67	73.60
727°	1000°	1.258	5.00	26.46	68.55
827°	1100°	1.359	1.13	32.85	66.02
927°	1200°	1.381	0.28	34.25	65.47
1027°	1300°	1.385	0.13	34.50	65.37

TABLE C.
IDEAL COMPOSITION OF PRODUCER GAS (GENERATOR GAS) PRODUCED WITH 50% OXYGEN.

Gasifying Temperature. t° C	T° abs.	Partial Pressure of CO+CO2 in atm.	Composition in Per Cents. by Volume. CO_2.	CO.	N_2.
Air Pressure—1 Atmosphere.					
227°	500°	0.50	50.00	.....	50.00
327°	600°	0.50	50.00	.....	50.00
427°	700°	0.502	49.40	0.80	49.80
527°	800°	0.522	43.40	8.80	47.80
627°	900°	0.568	29.60	27.20	43.20
727°	1000°	0.633	10.10	53.20	36.70
827°	1100°	0.66	2.00	64.00	34.00
927°	1200°	0.663	1.10	65.20	33.70
1027°	1300°	0.6655	0.35	66.20	33.45
Air Pressure — 2 Atmospheres.					
227°	500°	1.	49.56	.....	50.00
327°	600°	1.	45.65	.....	50.00
427°	700°	1.0035	34.03	0.61	49.83
527°	800°	1.0295	15.50	5.83	48.52
627°	900°	1.1065	34.03	21.30	44.67
727°	1000°	1.23	15.50	46.00	38.50
827°	1100°	1.308	3.80	61.60	34.60
927°	1200°	1.326	1.10	65.20	33.70
1027°	1300°	1.3305	0.43	66.10	33.47
Air Pressure 3 Atmospheres.					
227°	500°	1.5	50.00	.....	50.00
327°	600°	1.5	50.00	.....	50.00
427°	700°	1.5045	49.55	0.60	49.85
527°	800°	1.538	46.20	5.07	48.73
627°	900°	1.6345	36.55	17.93	45.52
727°	1000°	1.814	18.60	41.87	39.53
827°	1100°	1.9455	5.45	59.40	35.15
927°	1200°	1.986	1.40	64.80	33.80
1027°	1300°	1.9955	0.45	66.07	33.48
Air Pressure — 4 Atmospheres.					
227°	500°	2.	50.00	.....	50.00
327°	600°	2.	50.00	.....	50.00
427°	700°	2.0053	49.60	0.54	49.86
527°	800°	2.0443	46.68	4.43	48.89
627°	900°	2.1615	37.89	16.15	45.96
727°	1000°	2.384	21.20	38.40	40.40
827°	1100°	2.588	5.90	58.80	35.30
927°	1200°	2.6435	1.74	64.35	33.91
1027°	1300°	2.6605	0.46	66.05	33.49

Since it is not improbable that in future a mixture of 50 per cent oxygen and 50 per cent nitrogen may be used in gas producers, the data for this case are given in Table C. Fig. 3 gives the results graphically.

The following important general conclusions may be drawn from these tables and diagrams:

1. In all cases the CO_2 contact of the ideal generator gas at low temperature is a maximum, which is practically constant up to 400° C.

2. With increasing temperature the CO_2 content is decreasing; between 800° and 1,000° C. no CO_2 is present.

3. No CO is found up to about 400° C.

4. With increasing temperature the CO content is increasing and is reaching a maximum at 800° to 1,000° C.

5. At constant temperature the CO_2 content is increasing with the pressure, and therefore also with the oxygen content of the primary air.

6. CO shows the opposite property.

7. At low temperatures the absolute CO_2 content is increasing with the oxygen content of the primary air.

8. At high temperatures the absolute content of the gas on CO is increasing with the oxygen content of the primary air.

Therefore, the following facts have to be considered for getting a generator gas of the highest possible thermal value and also rich in CO.

1. The oxygen content of the primary air being the same, the gasifying temperature has to be high. In practice a temperature of 700° to 900° C. is sufficient, as at this temperature the maximum CO content is practically reached.

2. At high gasifying temperatures the quality of generator gas; i. e., the content of CO, is increasing with the oxygen content of the primary air.

3. High air (wind) pressures are unfavorable, as thereby, under otherwise constant conditions, the CO_2 content is increased. If, however, it is desired to generate the largest possible quantity of CO_2 in the producer, which is sometimes the case in the hot blowing period of the water-gas process for the purpose of rapidly increasing the temperature, a very low
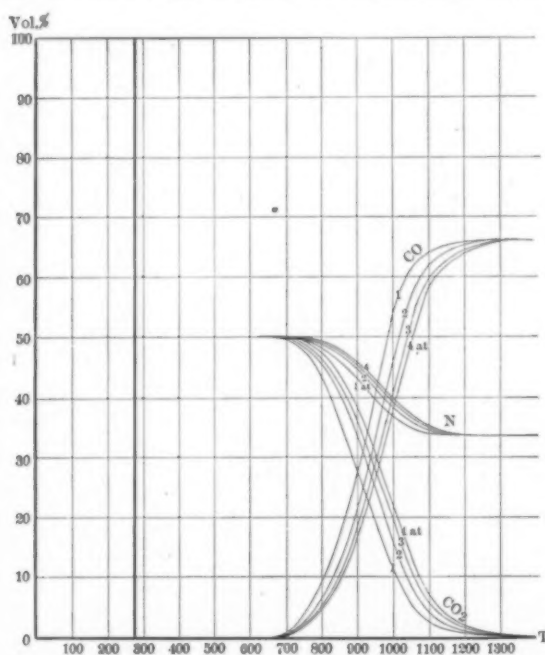

FIG. 3.—IDEAL COMPOSITION OF GENERATOR GAS FROM A MIXTURE OF 50 PER CENT O AND 50 PER CENT N.

temperature has to be kept during the process if the equilibrium is to be reached. This is easily understood, as with increasing temperature the quantity of the CO formed is rapidly increasing, and the quantity of CO_2 is decreasing. If in the producer the equilibrium is reached, the temperature of the producer must not get high if it is the intention to get a high yield of CO_2. These conditions are not changed by increasing the oxygen content of the primary air.

From the above facts we can calculate the volume proportions of CO_2 to CO, of CO_2 to $CO + CO_2$ and of CO to $CO + CO_2$, also the quantity of carbon gasified by a certain volume of air, the quantity of air necessary for gasifying a certain quantity of carbon, and also the quantity of carbon and air required for generating a certain volume of ideal generator gas.

We have so far treated the ideal generator gas; i. e., a gas which is produced by the action of dry primary air on glowing coal, under the supposition that in the process of combustion the state of equilibrium is reached.

We now have to consider the case in which the equilibrium is not reached, this case occurring very frequently in practice.

Every single layer of coke consists of pieces of coke and air spaces between. The larger the pieces of coke the larger the air spaces. With coke of fist size, the air spaces amount to one-quarter to one-fifth of the total volume, and these spaces allow the air to pass through the producer.

Every piece of coal, therefore, is surrounded by a layer of air varying in thickness from a few millimeters to a few centimeters. The reaction between the oxygen of the air and the coal takes place only on their contact points, and the question arises which reaction will occur first. The law of the gradual reactions states, that wherever several reactions might take place, the first reaction is that one which corresponds to the least stable state, then the next stable, and at last the most stable.

In our case we have but two possible reactions: The formation of CO_2 and CO, and we have to find out which one of the two is more stable. We, therefore. have to consider the free energies of formation of the two compounds.

Under the supposition that the concentration of the free oxygen is one atmosphere, we find that the curves of the two energies of formation go through the same point at a little below 1,000° abs. (about 700° C.), and that at lower temperatures the free energy of formation of the CO_2 is the larger one at higher temperatures, that of CO. We find the same relation in the stability of the two compounds, and, therefore, at the beginning of the reaction at low temperatures first of all CO, at higher temperatures first of all CO_2 will be formed. In rising upwards the gases will further react with the upper layers of coal and with the air contained in the interior part of the gas current.

The reaction of the outer part of the gas current with coal consists either in combustion of coal by means of CO_2 or in formation of carbon from carbon monoxide ($2CO = CO_2 + C$). Since at low temperatures first of all CO, if formed, the most plausible reaction under such condition is the decomposition of the CO and formation of C. The reaction, however, between the inner and outer parts of the gas current counteracts this decomposition, since the O of the inner part would burn any C which was deposited from the CO. The velocity of diffusion and mixture between the inner and outer parts of the gas current being sufficiently large, no C will be deposited, on the contrary, the CO formed will be burned to CO_2, and the oxygen going to the outer part will oxidize some more carbon. Therefore, the average composition of the gas will approach more and more the equilibrium.

At higher temperatures at first CO_2 is formed, and this will, by contact with the higher layers of coal, oxidize some C to CO. On the other hand, the oxygen of the inner part will tend to oxidize the CO present to CO_2.

In both cases we have two effects counteracting each other. At low temperatures the reaction between coal and outer layer of gas tends to prevent the reaching of the equilibrium, while the reaction between outer and inner layers favors the approach to the equilibrium. At high temperatures, however, we find that the reaction between gas and coal favors the equilibrium, and the reaction in the gas current works against it.

The conditions become still more complicated, if we consider that the actual velocity of the gas current at different points of the generator varies according to the unequal dimensions of the air spaces, and that also the temperature throughout the generator is not at all uniform. If the generator is working with the fire on top (maximum temperature in the upper parts of the charge), the state of equilibrium of the rising gas current is getting more and more favorable to the formation of CO.

The reverse is true with the maximum temperature in the lower parts of the producer. The location of the maximum temperature of the producer, however, changes during the

operation. In starting the fire the upper layer of the generator will be cold, and will allow the formation of CO_2. They are gradually heated up by radiation of heat from the combustion gases to the coal, and the hot zone will therefore extend from the bottom further upwards. After continued blowing we can imagine a coke column which has the combustion temperature of the hot carbon in cold air.

As will be seen from the above considerations the research of the generator process is extremely difficult, and we have but a few scientific investigations on this subject. One of the best is by O. Boudouard, even this being not free from objectionable points. He passed air at different speeds through a tube filled with charcoal and analyzed the gases obtained. He found at 800° C. the results given in Table D:

TABLE D.

Per Cent. by Volume.	Velocity in Liters per Minute.				
	0.10.	0.27.	1.30.	1.4655.	3.20.
CO_2	18.2	18.43	18.92	19.9	19.4
CO	5.2	3.8	1.88	1.83	0.93
O_2	....	0.47	0.94	....	0.93
N_2 (difference)	76.6	77.30	78.26	78.27	78.74

The analysis corresponding to the equilibrium at this temperature is

CO_2	0.92 per cent. by volume.
CO	34.32 per cent. by volume.
N	74.76 per cent. by volume.

It will be noticed that the gases from Boudouard's experiments are very high in CO_2 and very low in CO. In three cases they also contain free oxygen. This is in accordance with the fact that at 800° C. CO_2 is less stable than CO, so that, therefore, CO_2 must be formed first and the gas composition is approaching the equilibrium but gradually.

To better understand these conditions we are going to decompose the gases into the elementary components. We have in 22.42 liters of gas the amounts given in Table E.

According to the law of gradual reaction in the beginning, a thin layer of CO_2 is formed, which then oxidizes the coal layer through which it passes. It will, therefore, pretty nearly be correct to suppose that the outer layer (surface) of the gas current will have, shortly after its entrance into the tube, the composition which corresponds to the equilibrium. In this case the ratio of CO_2 to $CO_2 + CO$ must be equal to 0.0261. and there must have been formed the amounts given in Table F:

TABLE F.

Velocity in Liters.	Vol. CO_2.	Vol. CO.	Oxygen in Same.	Corresponding Amount of Air.
0.10	0.61	22.79	12.01	57.19
0.27	0.58	21.65	11.41	54.33
1.30	0.54	20.26	10.67	50.81
1.465	0.54	20.19	10.64	50.67
3.20	0.53	19.80	10.43	49.67

If we deduct the air volume actually used for the original combustion from the volume of primary air, we get the surplus quantity of air from which we can figure by a simple way the surplus air given in Table G and Fig. 4:

The following consideration will be still more useful for the practical regulation of this process:

We suppose again that in the first moment the least stable gas is formed, but that in a short time on the surface area the equilibrium corresponding to the actual gasifying temperature will be reached. In the further course of the process this equilibrium will, however, be disturbed by the gradual mixture

of the outer gas layer with the inner air volume, by the fall in temperature resulting therefrom, and by the combustion of a part of the original CO to CO_2, due to the surplus oxygen.

Referring again to Boudouard's experiments at 800° C., we can calculate from the free oxygen content of the gases the corresponding amount of air, deduct the latter from the composition of the gas, calculate the temperature of equilibrium corresponding to the gas mixture obtained, and compare the temperature of equilibrium with the actual gasifying temperature (800° C. = 1,073° abs.). We obtain thereby the results given in Table H:

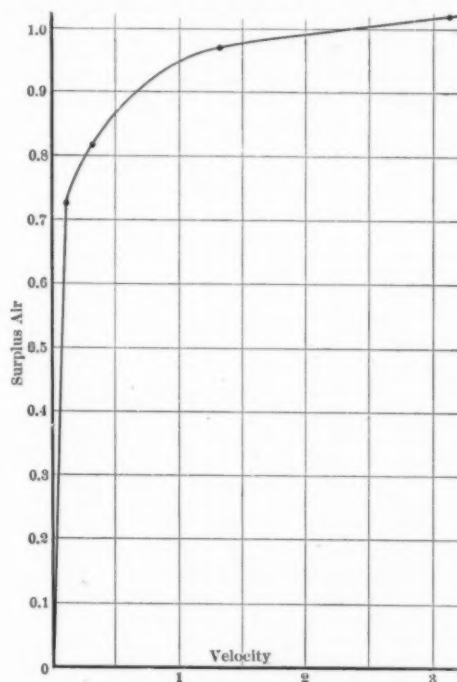As may be seen from Table H and from Fig. 5 the "ideal"

FIG. 4.—CURVE OF SURPLUS AIR.

(or apparent) gasifying temperature corresponding to the actual composition of the gas is clearly below the actual, and the curve of this difference of temperatures consists of two practically straight branches, which are connected with each other by a short, sharply bent piece of curve. In the one branch. which is practically vertical, the velocity of reaction is the main factor, while in the inclined branch the velocity of the wind is of main importance.

Naturally, the position and shape of this curve depends, not only on the gasifying temperature, but also on the size of coal uesd, and on the height of the fuel layer. Under conditions, however, which can be compared with each other, these additional factors will have the same character and the position of the bending point of the curve seems a very suitable characteristic point for the conditions.

With increasing gasifying temperature, the velocity of reaction increases, and the bending point of the curve will move to the right. Increase of the fuel height and decrease of the coal size will have a similar effect. In the latter cases, how-

TABLE E.

Velocity in Liters per Minute.	Gramatoms C in			Mol. Oxygen in					Primary Air.
	CO_2	CO	Total.	CO_2	CO	Free.	Total.	Nitrogen.	
0.	0.92	34.32	35.24	0.92	17.62	.....	18.54	64.76	83.30
0. 0	18.2	5.2	23.4	18.2	2.6	.....	20.8	76.6	97.4
0.27	18.43	3.8	22.23	18.43	1.9	0.47	20.8	77.30	98.1
1.30	18.92	1.88	20.80	18.92	0.94	0.94	20.8	78.26	99.06
1.465	19.9	1.83	21.73	18.9	0.92	.....	20.18	78.27	98.45
3.20	19.4	0.93	20.33	19.4	0.47	0.93	21.20	78.74	99.94

TABLE G

Velocity in Liters per Minute.	In 100 Volumes Generator Gas Volumes of			Of 100 Volumes Primary Air. For Original Combustion.	Surplus Air.	N Times Surplus Air.
	Primary Air.	Air for Original Combustion.	Surplus Quantity of Air.			
0.10	97.40	57.19	40.21	58.72	41.28	0.737
0.27	98.10	54.33	43.77	55.38	44.62	0.805
1.30	99.06	50.81	48.25	51.29	48.71	0.949
1.465	98.45	50.67	47.78	51.46	48.54	0.943
3.20	99.94	49.67	50.27	49.70	50.30	1.012

TABLE H.

	Velocity in Liters per Minute.					
	0	0.10	0.27	1.30	1.465	3.9°
Free oxygen, per cent. by volume	.....	.....	0.47	0.94	.....	0.93
Corresponding amount of air, per cent. by volume	.....	.....	2.24	4.48	.....	4.43
Composition of the gas free from air, per cent. by volume CO_2	0.92	18.2	18.85	19.81	19.9	20.20
CO	34.32	5.2	3.89	1.98	1.83	0.97
N_2	64.76	76.6	77.26	78.21	78.27	78.74
Gasifying temperature (absol.), corresponding to the composition	1073°	763°	749°	732°	729°	7002
Difference between the latter and the actual gasifying temperature, which is higher by.	0°	307°	324°	341°	344°	373°

ever, some other influences have to be considered, such as friction between gas current and coal pieces, heating of the upper layers by the rising gas, location of the maximum temperature in the generator, etc.

The following figures are given as practical results of generators that were charged with carbonized fuel.

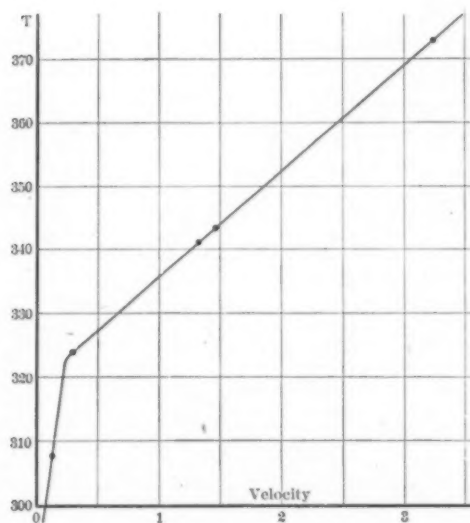Ebelman gasified at Audincourt small-sized charcoal in a

FIG. 5.—DIFFERENCE BETWEEN ACTUAL AND APPARENT
GASIFYING TEMPERATURES.

pressure producer, which had the shape of a small blast furnace, and he obtained a gas of the following composition (per cent by weight):

CO	34.1%
CO_2	0.8
N	64.9
H_2	0.2
	100.0

In a gas producer at Pous l'Eveque, which was charged with coke, he obtained a gas of the following composition:

CO	33.8%
CO_2	1.3
N	64.8
H_2	0.1
	100.0

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE IRON AND STEEL INSTITUTE MEETINGS.[1]

The second day's gathering at Great George Street was opened by Capt. ROBERT HUNT's presidential address to the American Institute of Mining Engineers. The speaker pointed out that the inception of the body he was addressing and the introduction of the Bessemer process into the United States were practically coincident. The address was, therefore, mainly descriptive of the history of the rise of the process in the United States of America, and the various statistical, economic and mechanical features of its development recited.

The conclusion of the address seemed to imply that in Capt. Hunt's opinion the Bessemer process had probably reached its zenith. Although the production of basic open-hearth steel rails was small, it was "the writing on the wall" and therefore significant. As to future developments in American metallurgy in general, he would place Mr. Gayley's work as next in importance to the gas engine using furnace gases. On behalf of his Society he had to present diplomas of honorary membership to Mr. Hadfield and Mr. J. E. Stead, as the highest honor that it was in their power to bestow on two distinguished English metallurgists. After suitable acknowledgment from the recipients the discussion of papers was commenced.

The first paper presented was that by Mr. ALBERT LADD COLBY, on "Comparisons of American and Foreign Rail Specifications," of which the author read an abstract. The paper was mainly devoted to a comparison of various specifications from the American standpoint.

The discussion was opened by Mr. Windsor Richards, who described phosphorus as the most undesirable constituent. The Bristol Engineering Standards Committee had fixed 0.07 per cent of phosphorus as the highest permissible proportion. Formerly the orthodox practice had been to specify 0.06, but the poorer ores now being used necessitated an increase. The manufacturers had asked for 0.08, but this was not conceded. Even Mr. Colby, able advocate though he was, could not have extorted 0.08 from the engineering standards committee. According to English ideas, Mr. Colby's standard of 0.10 or 0.11 was far too high, and such rails would not be laid down here.

Mr. Price Williams suggested that a copy of the paper should be presented to the engineers of English railways. What was wanted was practical information on the subject—there had been too many micro-photographs and chemical analyses. The serviceable life of the rail was more important than chemical constitution. What was really necessary was definition of the tonnage actually required to wear

an ordinary rail down one-sixteenth of an inch.

Mr. Harbord urged that specifications should be so drafted that they could be lived up to, and the British standard of 0.07 phosphorus was one which manufacturers here could live up to. The hardness varied with the carbon present, and also with the process acid or basic. With the Bessemer process higher percentages of carbon could be used, a proportion of 0.6 and 0.7 had recently given excellent results.

Mr. Hadfield then congratulated Mr. Colby on his paper, and remarked on the difficulty which Mr. Colby would have had if he had attempted to convert the engineering standards committee. As to rails with 0.1 per cent of phosphorus which had not broken, Mr. Colby had not mentioned the proportions of carbon and manganese present; low carbon and manganese permitted durability with high phosphorus. He suggested that Mr. Colby should send over several samples of different rails to be tested on the alternating-stress machine at the National Physical Laboratory.

Dr. Raymond then read two communications. The first was from Mr. E. F. Kenny, and declared that very convincing testimony had been furnished that nearly every American railroad now suffered from broken rails. The brittleness was undoubtedly due to high phosphorus, which was an unmixed evil. So long as its proportion was near 0.1 per cent it would be impossible to get rails which would wear well. The arguments advanced in favor of such high proportions were not sound. Further, the straightening was often carelessly done. He advocated a maximum cumber before straightening; rails in excess of the fixed quantity ought to be classed as No. 2 quality and sold as such. Another was the length which should be discarded from each rail in order to limit segregation. The second communication was from Mr. W. E. Freir, and referred to corrugations and roaring rails. These were a nuisance and source of monetary loss, the cause being shrouded in mystery, there being explanations galore, none of which held water.

Mr. J. E. Stead pointed out that in regard to phosphorus chemists and metallurgists were all agreed that if the carbon was raised the effects of phosphorus became more pronounced. He regarded 0.1 phosphorus as a maximum, but manufacturers liked to have a working margin above the figure of the specification, which latter they liked to treat as an average and not as a maximum. He was personally prepared to advocate the occasional acceptance of isolated rails up to 0.1, if these were only few in number, and if the carbon and manganese were low. He believed that high manganese caused more broken rails than high phosphorus.

Mr. J. E. York then remarked that the physical treatment of rails was of much importance. Several internal stresses were often occasioned by the irregular operation of mills. The reason why English rails did not break like American rails was because English rails were delivered at a uniform speed.

Capt. Hunt stated that he was absolutely convinced American processes would be forced to change, and that the limitation of high phosphorus would lose its present significance. Mr. Colby then wound up the discussion by asking permission to reply in writing to the many points raised. He reminded the audience that the specification which he had submitted required a vigorous drop test, which was a safe check on brittleness.

A paper by Mr. R. H. LEE on "The Gas Producer as an Auxiliary in Iron Blast Furnace Practice" then elicited a very brief discussion.

The third and last day was a joint meeting of the two societies, Mr. Hadfield presiding. Mr. JAMES P. ROE's paper on "The Development of the Roe Puddling Process" (page 353 of our last issue) was read in abstract, and the discussion opened by Dr. Raymond, who stated that the invention had provided a revival of the puddling furnace after its funeral had been announced and obituary eulogies delivered. Many complaints were now being made by farmers about their wire

fences. These had given much trouble, and in many parts had given way. Careful investigations into the matter had been going on for some time, and it was thought that the breakages were due to the manganese in the steel. The old wrought iron wire, it was said, stood much better than steel. He thought that so long as manganese was put in steel—and this must be done—then there would be an opening for wrought iron in certain cases. If engineers were again going to resort to the puddle furnace, then mechanical puddling must be adopted if the quality of the metal was to be as good in large as in small quantities.

Mr. J. E. Stead complimented Mr. Roe on his ingenuity and dogged determination in the face of difficulties apparently insuperable. Mr. Sahlin explained that he had seen the process at work, but when he first heard of it he regretted that so good a worker should risk his reputation on an attempt to resurrect an old process. Seeing it in successful operation. he had noted with pleasure the solid homogeneity of the product. The machine, too, was good as an engineering work, none of the penurious economy often found in experimental work being noticeable. Wrought iron manufacturers competed with steel makers for cast iron, the latter securing the higher grades.

Mr. E. S. Cook pointed out that wrought iron manufacturers were important to blast furnace owners, as customers for lower grades of cast iron; within certain limits the chemical constitution of pig iron did not trouble the puddler. Mr. Hartshorne praised the Roe process as a practical and technical success, and was sure it would be a commercial success. Mr. Kerr, as an old puddler, welcomed the machine, and wanted to know whether a high silicon iron would be treated in the same way as a low silicon iron. Mr. Paul attributed the elimination of silicon to the low temperatures Mr. Roe employed. He was surprised, however, that the development had not been carried a stage further, and the regenerative process adapted to the furnace. Had the Danks furnace been worked entirely with gas it would have been alive to-day. As to corrosion in iron and steel, much emphasis had been laid on manganese. Was not corrosion attributable to the galvanic action of the metalloids? The greater the number of the elements they introduced the greater the risk of galvanic action.

Mr. E. P. Martin pointed out that the most difficult question in puddling was that of the maintenance of the bottom of the furnace, which Mr. Roe had solved for his furnace. Prof. Bauerman remarked on the exceeding interest of the paper. and how rarely it was that inventors took audiences so fully into their confidence. As to rotary furnaces, these were generally spoken of in the past tense, but some still survived, a Creuzot modification of the Danks furnace being in use at Terni, in Italy. The original Danks furnace was weak in construction, and gave too large a ball for manipulation. The author now proposed to give a bloom double the weight of Danks. He did not feel sure of the propriety of this. Possibly a smaller mass would give better results. Prof. Turner supported Prof. Bauerman's view as to the large blooms, and said that the future of wrought iron would depend upon a good quality of material. Fiber and texture were of the utmost importance, and it had yet to be proved that the larger bloom would give a good enough texture.

A vote of thanks, moved by Mr. Hadfield, wound up the discussion on this paper.

The last item in the way of discussed papers was that by Mr. JAMES E. YORK on "Improvements in Rolling Iron and Steel." As to what was said, a leading English engineering paper characterizes the discussion as "short, uninteresting and irrelevant." This description lacks the word "farcical." The author was frankly and humorously autobiographical, and the walls, covered with paintings of solemn and revered past-presidents of the Institution of Civil Engineers, echoed to the laughter of the audience. Uninteresting, well, yes, if the low-

comedy touches in a tragedy are uninteresting. Irrelevant! well, yes, if the wit of the grave-digger in *Hamlet* is irrelevant. But in any case unusual, unaccustomed and undignified for such an assembly.

METALLURGICAL PAPERS AT THE BRITISH ASSOCIATION.

This year's British Association meeting, at York, was considerably ahead of its predecessors in the high standard of excellence of the papers secured. Section G, which is devoted to engineering matters, had a very strenuous time, the metallurgical papers alone being quite numerous. These included "The Deformation and Fracture of Iron and Steel," by Mr. W. Rosenhain; "Segregation in Steel Ingots and Its Effect in Modifying the Mechanical Properties of Steel," by Mr. J. E. Stead; "Structural in Nickel Wire at High Temperatures," by Dr. H. C. H. Carpenter; "A Magnetic Indicator of Temperature for Hardening Steel" and "Electro-Positive Coatings for the Preservation of Iron and Steel," by Mr. Sherard Cowper-Coles.

Also of indirect interest was Prof. T. Hudson Beare's account of "The New Engineering Laboratories at Edinburgh University and Their Equipment," as the contents of the testing laboratory was described, this containing a 100-ton Buckton machine, a 60,000-pound Riehle machine, and a 100-ton Amsler machine, specially designed for compression and bending work. Sir William Preece's paper on "Glow Lamps and the Grading of Voltages" was interesting on account of the large number of metallic filament lamps alluded to in the discussion.

MARKET PRICES DURING AUGUST.

The general activity of all manufacturing concerns, particularly those of the engineering trades, has resulted in higher prices for the chief raw material. Cleveland pig iron has advanced during the month from 51s 2d to 54s 6d per ton. Copper prices have been well maintained. There have been several bear attempts to depreciate prices on account of increased production. Nevertheless, the price has advanced from £82.5s per ton to £84.15s. Hand-to-mouth-buying is still going on here. Tin has advanced again during the month, having advanced from £175 to £182.10s. Friends in the Straits Settlements tell me of considerable activity in the tin mining industry. Lead is firm, English being quoted at £17.10s for prompt delivery. Antimony is easier at £105 per ton.

Platinum is quoted at 91s 3d per ounce.

Copper sulphate is firm at £25.5s. Ammonia sulphate is also 5s dearer, at £12.2s 6d. Prices of the coal tar products are fairly well maintained, liquid carbolic acid 97-99 per cent fetching 11d per gallon. Cyanides 98 per cent, minimum are fetching 8½d. Caustic potash has advanced 5s to £19.15s per ton, and prussiate yellow ¼d to 5¾d per pound. On the other hand, Montreal potash in store, Liverpool, is quoted £4 per ton lower at £31. The only change to be chronicled in regard to the soda products is the higher price of £11.5s for nitrate of soda.

LONDON, Sept. 1, 1906.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

ELECTROMETALLURGY.

Preparation of Molybdenum in the Electric Furnace.— Dr. C. Lehmer, in *Metallurgie*, Aug. 22, gives an account of the experiments which he undertook with molybdenite in the electric furnace, for the purpose of producing metallic molybdenum and molybdenum alloys. The equation which he attempted to realize for obtaining molybdenum was $MoS_2 + 2CaO + 2C = Mo + 2CaS + 2CO$. After several trials with varying amounts of material, and increasing the quantity of lime considerably above that required theoretically, he smelted a charge of 1,500 grams MoS_2, 1,400 grams CaO and 385 grams C, and obtained a yield of 85 per cent, of a metal of the following composition: Mo 88.3 per cent, Fe 2.89 per cent, Si 2.95 per cent, S 0.04 per cent and C 5.6 per cent. The melting was done in a furnace of the Héroult type. For producing ferro-molybdenum he smelted a charge of the following proportions: MoS_2 2,500 grams, Fe_2O_3 2,150 grams, $CaOO_2$ 4,160 grams and C 999 grams. The analysis of the metal obtained was: Fe 46.56 per cent, Mo 48.72 per cent, Si 2.61 per cent, S 0.13 per cent and C 1.06 per cent. The metal produced formed a coherent regulus and had a silver-gray color, but was still very hard, notwithstanding the small amount of carbon it contained. For the production of chrome-molybdenum, the author used a charge of 1,218 grams of Cr_2O_3, 960 grams MoS_2, 1,200 grams $CaCO_3$ and 600 grams C. The analysis of the metal obtained showed Cr 53.44 per cent, Mo 34.10 per cent, Fe 3.71 per cent, Si 0.21 per cent, S 0.09 per cent, C 7.4 per cent. The charge was briquetted with tar. The yield of metal was 83 per cent. The next experiment was made with the addition of CaO, the carbon being only in the form of tar residuums, obtained by repeated briquetting and ignition. The charge contained 609 grams Cr_2O_3, 480 grams MoS_2 and 896 grams CaO. The analysis of the metal gave

Cr 57.21 per cent, Mo 36.10 per cent, Fe 3.82 per cent, Si 0.30 per cent, S 0.07 per cent and C 2.1 per cent. The yield was 79 per cent. The color of the alloy was silvery white, the hardness about No. 9 of the scale, and it could easily be broken with a hammer. The experiments thus far described were made in a furnace lined with magnesite. The next experiments were made in order to produce nickel-molybdenum from a charge of 1,195 grams NiO, 640 grams MoS_2 448 grams CaO and 280 grams C, the charge having been briquetted with a small amount of tar. The yield was 89 per cent. The color of the alloy obtained was that of pure nickel, and on account of its soft nature it could be easily flattened out with a hammer. It had the following composition: Ni 69.26 per cent, Mo 26.15 per cent, Fe 3.12 per cent, Si 0.30 per cent and S 1.23 per cent. The comparatively large amount of sulphur is to be charged to the quantity of lime being only the theoretical amount. An experiment with a larger amount of lime, in a charge composed of 1,195 grams NiO, 640 grams MoS_2, 760 grams CaO and 300 grams C, gave the following alloy: Ni 68.67 per cent, Mo 26.05 per cent, Fe 2.61 per cent, Si 0.27 per cent, S 0.07 per cent and C 2.10 per cent. The yield of metal was 85 per cent. Another charge made up of 472 grams NiO, 640 grams MoS_2, 760 grams CaO, 250 grams C, composed of material of 2 to 3 millimeter size and not briquetted, gave an alloy of the following composition: Ni 48.53 per cent, Mo 49.10 per cent, Fe 1.86 per cent, Si 0.25 per cent, S 0.18 per cent and C none.

METALLURGY—COPPER.

Copper Converter Melting its Own Matte.—Owing to the reconstruction of the blast furnace plant of the British Columbia Copper Co., at Greenwood, B. C., it becomes necessary to convert a quantity of copper matte and to melt it in the

converter. According to the *British Columbia Mining Record,* July, the converters at the plant are of the horizontal trough type, 84 inches in diameter by 126 inches long, with about 4,500 cubic feet of free air available at 10 pounds pressure. In order to melt the matte, a fire was first lighted in the bottom of the converter, and when this was thoroughly alight, about 1,500 pounds of coke were dumped on it and a light blast of air put on. When the fuel became red hot all through, some 3 tons of cold matte were placed on top of the brightly burning coke, and the full pressure of air was turned on. The matte quickly melted and more matte was immediately added to increase the volume of the charge. When this was melted in turn, the slag was skimmed off and still more matte was added, the operation being repeated until there was sufficient matte in the converter so that the charge could be properly converted. An average of 3½ hours was required from the time of commencing to fire the cold shell until the blister copper was poured. About 15 tons of 40 to 50 per cent matte was converted in one stand in one ordinary shift. It was found that a 45 per cent matte could easily be handled in the manner described above and finished hot. Matte up to 55 per cent was also successfully converted, but with this more care was required to maintain the requisite heat, and occasionally it was found necessary to add a few hundred pounds of coal to prevent freezing of the charge. The operation, of course, is not economical, but shows what can be done in an emergency.

LEAD.

The Huntingdon-Heberlein Installation at Nelson, B. C. —The new installations for the treatment of complex lead ores at the above mill by the Huntingdon-Heberlein process are described by H. Harris in the July issue of the *British Columbia Mining Record.* The process, as is well known, consists in partially roasting at a high temperature a mixture of fine crushed lead sulphide ore with carbonate of lime, the granular product being subjected to the action of an air blast in a cast-iron hemispherical pot. Practically, all the ore used has to be pulverized to a 6-mesh, and it is, therefore, crushed in a large Gates gyratory crusher, sampled, passed through rolls and brought into the bins. Automatic feeders are provided at the foot of these bins, by means of which the ore is fed onto a conveyor belt and discharged into a cylindrical mixer. This in turn discharges into a bin from which the roasters are charged. The new roaster installation contains one Merton roasting furnace, converted and enlarged to adapt it for use with the new process, and one 30-foot Huntingdon roaster, provision being made for a second. This machine has 50 tons capacity per day, and differs from most rabble-stirred automatic roasters in that the rabbles are fixed to the roof, and the circular bed, which is 26 feet in diameter, revolves, thus pushing the ore against the rabbles. The partially roasted ore from the mechanical roasters drops against a water spray into a large bin, whence it is conveyed to small bins located above the converters. The latter are six in number, 9 feet in diameter, and of a hemispherical form. They stand 17 feet above the dumping level, and are supplied with air by a No. 7 Connellsville blower. They are surmounted by hoods connected by telescopic pipes to a fan 7 feet in diameter, which serves to draw away the said fumes. One converter holds from 12 to 15 tons of charge, and the desulphurization requires from 8 to 12 hours. At the end of that time the converter is inverted and the contents are dumped on the floor below, where the mass is broken roughly by means of a drop weight operated by an electric hoist and by means of hand labor. The broken sintered product is pushed down a chute into a side dump-car, which automatically runs to and discharges its contents into storage bins situated on the railroad track, whence they are transferred to bins alongside of the blast furnace, where the material receives its final treatment.

GOLD AND SILVER.

The Pohle-Croasdale Process at Mayer, Yavapai County,

Arizona.—The Pohle-Croasdale process depends essentially upon the chlorination of the precious metals and their volatilization as the chlorides and subsequent condensation. The ores are crushed dry, mixed with salt and subjected to an oxidizing atmosphere of 1,000° C., as above. The chemical equation $2NaCl + S + 2O_2 = Na_2SO_4 + Cl_2$ shows the necessity for sulphur being present. As the amount of chlorine must exceed the theoretical amount required, the percentage of salt to be added must, of course, be greater than the theoretical required by the equation. With an average ore the limits are said to be placed at from 5 to 12 per cent of salt, but with higher lead and copper contents more will be required in order to volatilize these metals. The relative proportion of salt to sulphur, as expressed by the equation given above, is 10 per cent salt to 2.3 per cent of sulphur. In practical tests it was, however, determined that when over 3 per cent of sulphur is present, roasting is necessary, as otherwise the amount of salt consumed is too high. The practical application of the above process at the new plant of the Rigby Mining & Production Co., at Mayer, Yavapai County, Arizona, is described by Mr. O. H. Fairchild in *Mining and Scient. Press,* Sept. 1. This is the first application of the process on a large scale. The ore is crushed and dried and thoroughly mixed with salt in a square box made of sheet steel, patterned after a cement mixer. It then is fed into the furnaces, which consist of wrought iron cylinders with ½-inch shells, 5 feet 6 inches in diameter at the feed end, and 7 feet 6 inches inside diameter at the discharge end. They are 36 feet long. and lined with 6 inches of firebrick. They have a series of standard brick projecting 3 inches beyond the inside surface of the lining, which serve as rabbles. The fire-box is situated at the discharge end of the furnace, while at the feed end is a smoke-box 4 feet x 6 feet clear on the inside. The ore after treatment is discharged at the firebox end into a conveyor, which takes it to the dump. The fumes are conducted by a pipe, 4 feet in diameter, from the smoke-box to the inlet collection chambers. The latter are of brick, 12 feet 8 inches long by 5 feet 2 inches wide, the inlet chambers being 6 feet high, while the outlet chambers are 5 feet high. Midway between them is a chamber 5 feet square and 5 feet high, on which rests the center portion of the M pipe. The chambers are so built that from the inlet where the gases are introduced, they pass through an A pipe 20 feet high at the apex, rising and descending to the outlet chamber. The gases then return to the inlet through an M pipe of equal height, and then pass back from the inlet to the outlet chamber again through another A pipe. These pipes have a total length of 200 feet and a diameter of 3 feet; they are built of sheet steel. The fumes are then forced by a Root blower into the condensing chambers, which latter are located in a building 96 feet long by 44 feet wide. One-half of which is 28 feet high, while the other half, containing the bag houses, is 40 feet high. The condensing chambers are 21 feet x 16 feet, and are built 6 feet high of brick, and plastered on the sides and bottom with smooth cement. At the height of 6 feet from the floor is a sheet-iron floor, which contains apertures for fifty-four 18-inch flannel bags, 30 feet long. The materials obtained in the collection chambers, condensing chambers and bag houses are taken to the filter house, where the copper is separated. From there the solution goes to the precipitation house, which contains tanks for the precipitation of the copper, the only commercial metal contained in the solution. It is stated that 50 or 60 minutes will volatilize the gold contents of an ore with a furnace temperature of 1,000° C. or above. The gold volatilizes as chloride or possibly as double chloride with sodium, but these break up soon after leaving the furnace and metallic gold is deposited. The silver sublimate is deposited as chloride or sub-chloride, insoluble in water or dilute acids. The lead sublimate is a mixture of both the chloride and sulphide salts. The copper volatilizes readily, but the time required is usually 2 to 3 hours, if a considerable amount of copper is present. The sublimate is composed of

cupric, cuprous and oxy-chlorides principally. Zinc compounds volatilize very imperfectly, so that 50 to 70 per cent of the original zinc is left in the residue. Nickel and cobalt appear to behave much like the zinc.

Cyanide Practice with the Moore Filter.—The first instalment of an article by R. Gilman Brown in the *Mining and Scientific Press*, Sept. 1, deals with the practice at the Standard mine at Bodie, Cal., in the treatment of the slimes. The ore consists of quartz, iron oxides and clay, the latter a result of the decomposition of the feldspar in the country rock. This on an average is 33 per cent. The gold is partly coarse and partly very fine, and the latter portion amalgamates very badly. The proportion of silver is high, and the ore is difficult to treat, although all minerals ordinarily classed as deleterious are absent. In conjunction with the introduction of the Moore method weak cyanide solution was substituted for water in the 20-stamp mill, the grade of the plates being increased from 1½ to 2½ inches per foot, for the purpose of cutting down the proportion of liquid to keep the plates clear. This steep grade, combined with the hastening effect of the cyanide on the amalgam resulted in lowering the extraction by amalgamation from 60 to 50 per cent. The strength of the cyanide solution was found by experiments to give the best results at 2 pounds per ton, but lately the lower plates where the amalgam lays the thinnest have shown signs of wasting, and some have been renewed. Ten pounds per ton of lime are added to the ore before it goes to the crusher. After passing over vanners, the pulp is conveyed to the slimes plant, where it goes to two cone separators. The latter are of wood, approximately 5 feet deep, and have a 60° slope. The underflow, which contains the coarse stuff and a certain portion of adhering slime, passes to the tube mill, and is mixed with sand and slime from the ponds, automatically fed into the stream. The mill makes 26 r. p. m., and is charged with about 12 tons of Greenland concretionary flints, which charge fills the mill a short distance above the middle. This charge seems the best for grinding and most economical for power, according to the author, but the difference is not great, and the charge can wear to half this quantity with small diminution of grinding. After unsatisfactory trials with cast iron and wooden, as well as silex linings, wrought iron plates were finally adopted. These plates are ⅞ inch x 8 inch, cut into 7 and 15-foot lengths and bolted through the shell. The average life of these is stated to be over 100 days, and the duty 4,800 tons of sand, ground to 200-mesh. The consumption of pebbles is given as 6.47 pounds per ton, the wear of the lining being 2.44 pounds per ton. The wrought iron lining can be worn down thin without breaking, and it can be inserted in 10 hours. The power required for driving the mill is approximately at 50 hp. when running, and 100 hp. when starting. The maximum grinding capacity of the single unit is stated not to have been definitely reached, but it may safely be placed at 60 tons of sand per 24 hours, the duty of a horse-power-month thus being 36 tons. The normal cost of electric power in California, the power cost comes to 17 cents per ton, while at the Standard mine, which produces its own power, it is 5½ cents. The author states that experiments have also been made with a modified pan for fine grinding. It was found that a single 5-foot pan had a capacity of about 5 tons per 24 hours, and consumed 10 hp. Thus, from eight to nine pans were required to handle the coarse product of twenty stamps at a marked increase of power cost. No determination was made of the wear of metal, but judging from experience with grinding concentrate, it would be high, while the labor of attending to a battery of pans would also probably be large. The author, therefore, is of the opinion that altogether for a small plant, as far as this experience goes, three smaller tube mills, any two of which could do the whole work, would be preferable to pans, and probably cheaper in installation than two large units.

Device for Cleaning Battery Plates Without Stopping the Stamps.—In order to save the loss of time occasioned by stopping the stamps when it becomes necessary to dress the battery plates, Mr. W. Beaver, at the Globe & Phœnix Co. mill, Johannesburg, Transvaal, constructed an appliance which he describes in a paper before the Chemical, Metallurgical and Mining Society of South Africa, which is published in the journal of the Society, June, 1906. Fixed to the top of the chuck block, and immediately beneath the screen frame, he arranges a catch plate of sheet iron, 8 inches wide, which deflects the pulp outwards, and thus allows of a satisfactory sample being taken. When running in the usual manner, the pulp falls from this catch plate on a baffle-board, which deflects it back onto the mortar lip. When, however, it is intended to dress the main plate, this baffle-board is removed, and the pulp deflected into a sheet-iron launder, resting on chains fixed to the sides of the table frame, which carries the pulp from the catch plate to one side of the plate. There it enters a portable launder, 14 feet x 6 inches x 6 inches, which conveys it to a permanent launder running the full length of the mill. This permanent launder discharges into a distributing box placed at the head of an extra plate, 12 feet x 5 feet, situated outside of the mill. The plate has a lock-up cover and is dressed each time immediately before dressing the main plates. When a plate is to be dressed the amalgamator first puts the portable launder into position and then adjusts the sheet iron trough, after which the pulp flows directly to the extra plate described above. The screen is covered with a piece of canvas to prevent splashing, and two pieces of sheet iron pushed into saw cuts in the screen frame at each end serve to throw the pulp from the corners of the screen frame towards the center of the catch plate. Splashing and leakage onto the main plate are therefore prevented. The author states that the device has been quite satisfactory, the main plate being quite dry and clean during dressing and steaming. The extra plate only runs 4 hours and 20 minutes, but it behaves quite normally. He figures that the time saved in this mill, which would have been been consumed by stopping the stamps, amounts to a total of 9 days and 2 hours per year, which in his forty-stamp mill represents an extra crushing capacity of 1,816 tons, with practically no extra cost except the steam for the stamps. The saving in cam sticks alone is considerable.

Treatment of Zinc Gold Slimes Before Smelting.—As a substitute for the ordinary treatment of zinc slimes by the sulphuric acid process, Mr. C. E. Meyer, in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, June, 1906, proposes a treatment with ammonium carbonate, for which he claims various advantages. The important feature of the process consists in the previous oxidation of the slimes. They are taken from the precipitation boxes and placed in a vat, where they are brought to complete dryness by steam pipe attachment. During this procedure oxidation sets in, and any incomplete oxidation is hastened and perfected by moistening the slimes with nitric acid. Not much acid will be necessary, as the slimes oxidize easily, and any excess of the acid must be expelled by heating. This process of oxidation must be carried out with care, and an excess of acid must be avoided, as this will cause an unnecessary expenditure of time and money. The easily decomposed cyanides are thus oxidized while those cyanides which are only decomposable with difficulty, will be acted upon by the subsequent treatment with ammonium carbonate. The next step in the process consists in the addition of a preferably saturated solution of ammonium carbonate, the quantity required being about ten times the volume of slime under treatment. This ammonium carbonate throws down metals such as zinc, silver and copper as precipitates, dissolving in the excess of the reagent. Experiments on the same quantity of slimes, according to the author, resulted when the sulphuric acid process was used, in the production of a very heavy filtrate of a viscous nature, which filtered slowly, the residue on the filter containing a considerable quantity of zinc and copper. On the other hand,

the ammonium carbonate process gave a light, clear filtrate, while the bulk of the residue on the filter was considerably less and showed no zinc and copper. He claims, therefore, that the process has the advantage of superior filtering qualities and a complete elimination of the base metals, beside greater ease in handling. The filtrate from the filter press is kept and distilled over with powdered limestone or dolomite in a large boiler, by which means the ammonium carbonate is driven off and a by-product of a matte consisting of silver, lead and copper is left. The ammonium carbonate is obtained in solution by arranging a spraying device in the condensation chamber.

Observations on Tube Milling.—Tube milling of gold ores is a subject which engages considerable attention in metallurgical circles all over the world, and a good deal of important work is being done to ascertain the most favorable conditions for running the tube mill. A recent contribution to the subject is a communication of Mr. E. J. Laschinger, before the Chemical, Metallurgical and Mining Society of South Africa, in the Society's monthly journal for June. He investigates the causes of the wear of the silex linings and comes to the conclusion, based upon microscopic examination, that the grinding action of the pebbles on the lining is of much greater importance than the chipping action. By chipping action is not meant the loss of weight which the blocks suffer by flakes being chipped off their sides, but rather the impact of the pebbles striking anywhere on the surface of the liner and causing the loosening of small particles of the material. For the same duty, the wear must be in some measure inversely proportional to the area of the effective wearing surface. If it is assumed that the cement in the joints is not an effective wearing surface, it follows that the greater the percentage area of joints the less the effective area and the greater the rate of wear. Carefully measured, it would appear that the ordinary silex blocks, as used at the Robinson Deep Mill, which measure on the average 7½ x 4½ x 2½ inches, when placed as closely together as possible, have, when set flat, an effective wearing surface of 95.4 per cent of the circumference of the tube mill, while, when set on edge. the effective surface is only 86.1 per cent. These are in the ratio of 111 to 100, and if the wear be inversely proportional to the effective surface, the rates of wear will be in the above ratio. It thus is evident that blocks should be made as large as possible, with due regard, of course, to other practical considerations, and that the joints should be made as close as possible when setting the blocks. The pulverizing effect of the tube mill is the greater the less the amount of water introduced with the feed. As the chief cause of reduction is probably the crushing action on particles caught between individual pebbles falling on each other, this may be explained by the cushioning of the blows by the water. The author thinks, therefore, that there may be two ways in which the efficiency of wet grinding can be increased and the life of the liners be prolonged, and that is (1) by introducing as little water as possible with the feed, and (2) by allowing any surplus water introduced into the mill to drain out quickly, thus leaving the particles to be ground as dry as possible. He suggests that this second method of increasing efficiency might be attained by having the discharge plate or screen of the tube mill in the shape of a disc, and perforated all over its area, so that the water could drain out as quickly and thoroughly as possible. Two other important factors in the life of liners may be the pebble load and the speed of the mill, and even small differences may account for large differences in the life of the liners and the wear of the pebbles.

Tube Mill Practice.—Mr. S. S. Osborn, in the journal of the Chemical, Metallurgical and Mining Society of South Africa, June, contributes some remarks on the practical operation of tube mills. He lays stress again on the importance of a good classification of the pulp, and thinks that the present arrangement of dewatering spitzkasten on the Rand fields is not altogether satisfactory. The pulp falls from too great a height into the center of a spitzkasten much too small, with the consequence that a larger proportion of sands, etc., is carried over the side instead of passing through the tube mill, thus causing an increase in the quantity of pulp in circulation. This difficulty can be to a certain extent overcome by placing a sleeve around the inlet pipe and baffle below, as is done in the slimes collecting tanks. When ores are heavily charged with marcosite, as is the case in the Glen Deep and the Robinson Deep mines. fine grinding has to be resorted to, and according to the author every effort should be made to grind all pulp sufficiently fine to allow of its passing through a 60-mesh screen. The author states, that as far as the feed end of the tube mill is concerned, where the outlet of the mill is much larger than the inlet, nothing need be added to prevent the pulp from flowing out at the inlet end. On the other hand, however, where there is not much difference in the size of the inlet and the outlet, there is a tendency for the pulp to pass out at the feed end, and, therefore, the gland and top feed were adopted in the Allis-Chalmers mill. He thinks that there seems no necessity for any elaborate fixture on the feed end, as a thin disc, with a 5-inch hole in the center, attached to feed end, prevents the pulp from flowing out, while it is not a difficult matter to feed in the required amount of pebbles through the 5-inch hole. At the discharge end of the tube mill. excellent results have been obtained at the Glen Deep mill by replacing the screens supplied by the makers by a plain disc of white iron, 1½ inches thick, and perforated with holes tapering from 1 inch to ⅜ inch. Broken pebbles cannot become lodged in such a hole. As far as the pebbles are concerned the author maintains that the secret of low pebble consumption is to pass a large tonnage of pulp through the mill, so as to insure having a cushion of that material between the pebbles when they are striking one another in the mill. To substantiate this statement he gives the following results:

Liners.	Life. Days. Hrs.	Battery Screening 200-150	Tons Crushed in Battery.	Pebbles Fed In.	Tons per 24 Hours Through Tube Mill.	Pebble Consumption per Ton Crushed in Battery.
Chilled Iron	29 21	100	64	2.186	6.541	93	3 lbs.
Silex.......	51 1	64	100	11.727	31,040	389	2.65
Manganese Steel.....	97 18	100	200	25,810	36,700	522	1.42
Silex.......	49 —	100 200 400	27,354	16,250	617	.59

In most cases the tonnage passing through the tube mill was larger than the total tons crushed by the stamps, owing to having a larger quantity of pulp in circulation.

Filter Pressing for Clarifying Gold-Bearing Solutions.—The results obtained by using two small Johnson filter presses for clarifying the precious metal-bearing solutions coming from the slimes plant and going to the precipitation boxes, are given by Messrs. S. J. Truscott and A. Yates, in a paper read before the Chemical, Metallurgical and Mining Society of South Africa, printed in the July issue of the journal of that Society. The presses had each thirty-four cells, 30 inches square and 2 inches deep. Previous to the utilization of the presses the solutions from the slimes plant, amounting to some 300 tons per 24 hours, passed along a launder, where a little slump slime was added at intervals. This launder discharged into a 13-foot x 5-foot settling tank, which overflowed into an 8-inch x 5-inch tank, and this again fed another one of similar size, from which the solution was pumped up to the extractor house. There it passed through a 6-foot x 6-foot tank before entering the zinc boxes. Slime settled in all these tanks and was from time to time cleaned out, but much also settled in the extractor boxes and fouled the precipitate, though the solution had but little appearance of turbidity. At the present time, as the two Johnson presses are used, the addition of lime is dispensed with. The solution is pumped from the first settling tank into the presses, from which it issues crystal clear. The pump used is an Evans steam pump of 5-inch diameter and 12-inch stroke, operated by compressed

air, which serves also as a reserve solution lift pump. The presses are opened twice a week, and the clothes well scrubbed to free them from fine slimes. The filter cloths which have already been in use two months in the zinc gold slimes filter press, and have become hard in that service, are still effective for another month in clarifying the solutions. The authors remark that the beneficial effects of this filter press clarification upon the solution were at once felt in the smelting. The precipitate became clear and was easily reduced. Thus, for instance, in January, 1905, with the settling tanks. and a total recovery of 2,269.8 ounces of gold and 17,853.7 ounces of silver, the cost of smelting per ounce of fine gold recovered was 27.2d and the cost of smelting per ounce of fine metal recovered was 3.07d. On the other hand, in Dec., 1905, with the clarifying presses, and a total recovery of 3,336.8 ounces of gold and 19,510.4 ounces of silver, the cost of smelting per ounce of fine gold recovered was 6.01d. and per ounce of fine metal recovered 0.87d. The authors think that one press would be sufficient if more frequently opened, and if that press were of the inside-closed channel type. the force pump which sent the solution into the press would also force it into the extractor boxes wherever they were.

Treatment of Silver Lead Tailings by the Cyanide Process.—A description of the method used for cyaniding silver lead tailings at the Winters mine, in Douglas County, Nevada, is given by the manager, Mr. E. J. Sweetland, in the *Eng. and Min. Journal*, Aug. 25. The low-grade ores, which remain after sorting out the shipping ore, are treated by crushing in quadruple issue mortars, the pulp being passed over New Standard concentrators. The value of the ore is principally in lead and silver, the lead being commonly present as carbonate, though galena is also present. When the concentrators are properly adjusted the galena is found in the outer streak of concentrates, and is followed by a well defined streak of lead carbonate, running well in lead and silver and almost free from sand. Inside of this is a darker streak, carrying lead and silver and some sand. the percentage of which gradually increases as it approaches the tailings end of the table. It was found that the most economical point for separating the concentrates from the tailings was at the center of the streak last mentioned. The tailings are run into one of three reservoirs, and are allowed to settle. The tailings average 1.25 per cent lead and 0.11 per cent copper, with traces of zinc, arsenic and antimony. The copper is largely present as carbonate, which is readily attracted by potassium cyanide. The average value is 0.41 in gold and 7.6 ounces silver per ton. It was found that it was possible to treat the tailings without an excessive consumption of cyanide, on account of the silver existing largely in the form of cerargyrite or chloride. Thus a fair amount of silver could be dissolved with a solution so dilute as to have little effect upon the salts of copper and lead. A series of laboratory experiments were run in order to determine the best form of treatment. It was found that on account of the selective action of the cyanide for chloride of silver, practically as much is dissolved by a solution of 0.1 per cent KCy as by a stronger solution, while the base metals are not as strongly attacked by the weaker solution. It was also ascertained that the extraction could not be materially improved by combined contact with a weak solution. The laboratory experiments were confirmed by practical results. The cyanide plant consists of four leaching vats, each 17 feet in diameter, with 4-foot staves, fitted with a false bottom of slats covered with a layer of burlap and 6-ounce duck. The burlap and duck are held in place by a ¾-inch hemp rope driven in a groove between the staves and the false bottom. There are two 10 x 10-inch bottom discharge doors in eac hvat. The vats are connected to two collecting tanks by a double line of 1½-inch pipe. There are sixteen circular sheet-iron boxes in two rows of eight each, 16 inches in diameter and 18 inches high, each provided with a screen 2 inches from the bottom, and a baffle-board to direct the flow under the screen. The author states

that though this seems to be a very small zinc-box capacity for a plant treating silver ores, he found it to be ample. The solution after reaching the sump is returned to the stock tanks by a Gould rotary pump, actuated by a 3-hp. Fairbanks-Morse gasoline engine. The vats are filled by a wheeled scraper and leveled, and are charged with solution from below. Immediately when the solution covers the surface of the charge, the flow is stopped from below and turned on at the top, leaching being commenced at once, omitting the customary period of soaking. The solutions are allowed to percolate unrestrained, but when a solution leached too freely on account of lack of slime, it was found of advantage to cut down the flow, as the passage of too great an excess of solution increased the consumption of cyanide. The clean up of the zinc slimes is affected in the usual manner, the solution being carried out in a redwood tank, which gave excellent satisfaction. The resulting bullion was about 750 fine.

POWER.

Electrical Equipment of the El Oro Mill.—In a lengthy article on the recent devlopments in the installation of electrical machinery in the mills of the El Oro mines district, C. V. Allen, *Engineering Magazine,* September, gives some data regarding the use of electricity in the mill of the El Oro Mining & Railway Co. The total amount of power used amounts to some 4,000 hp. All the motors are three-phase, 50-cycle (6,000 alternations) machines, and as a rule they are 400-volt induction motors for 200 hp. and less, and 3,000-volt synchronous motors above 200 hp. For the older mill, No. 1, the main stamp shaft was formerly rope-driven from its engine, but it is now driven by a 350-hp. synchronous motor, making 187 revolutions. From this main shaft a belt drive transmits the power to the cam shaft• of the batteries in groups of ten stamps.

This cam shaft makes close to 51 r. p. m., thus giving the stamps about 100 drops per minute. The stamps weigh about 1,000 pounds, and are lifted 6 inches. The duty per stamp is 4.7 tons per 24 hours. This motor, and all other synchronous motors, is started by means of a small variable-speed induction motor, by single gear reduction, the pinion on the starting motor shaft being on a feather-key. The motor can thus be cut out of service by a hand lever after the large motor is up to synchronism and connected electrically to its circuit. The new mill has been also provided with a steam plant, to be put into service quickly if anything happens to the electric power supply. Thus the 550-hp., 88-revolution, two-bearing synchronous motor which drives the 100-stamp battery and three tube mills, and the 260-hp., 88-revolution, two-bearing synchronous motor which drives the cyanide plant, were constructed with shafts extended on both ends to receive half couplings, the motors being installed between engines and shafts, to be driven with all shafts in each set in line. A flexible coupling of rubber cylinder type connects motor and driven shaft, and a special semi-flexible form of key-plate coupling connects motor and engine shaft. Normally the bolts and the middle or key section of the latter couplings are left out when the motors are driving. In 15 minutes or less they can be put into place, thus allowing the engines to drive the shafts, revolving the rotors of the motors at the same time. This has thus far, however, not been found satisfactory. Concerning the three tube mills at El Oro, the author remarks that smaller mills were adopted in the new installation, as they had proved to give the most satisfaction and least trouble in mill No. 1.

The "Danish" pebbles used cost $36.80 per ton at the mill, and the average pebble consumption is given as 5 pounds per ton of sand. The lining is composed of cast iron strips, the consumption being roughly ½ pound per ton of sand. The author states that for the slimes treatment the cost for steam drive was $0.90 per ton, while it is $0.50 at present for electric power.

Costs.

The Cost of Smelting Copper Ore.—In an article in the *Engineering and Mining Journal*, Sept. 1, G. F. Beardsley discusses in general the factors which go to make up the cost of copper smelting, so as to give a basis for figuring upon the question whether it pays to work a given low grade ore deposit. The first example he gives applies to the Mt. Lyell mine, of Tasmania, the ore of which is an exceptionally pure pyrites, which contains about 2.3 per cent of copper, 2 ounces of silver, and $1.40 gold. The average composition of the ore is: Iron 40 per cent, sulphur 46 per cent, silica 5 per cent, baryta 2 per cent, alumina 2 per cent. The ore is treated by pyritic smelting. The first product is an 8 to 10 per cent copper matte, which is concentrated by a second smelting to converter matte containing 35 to 40 per cent of copper. The deposit is worked by the open cut system, and therefore an item, "removal of overburden," is included in the following cost sheet. The item of smelting includes labor, coke, fluxes, power, heating blast, stores, water supply, flue dust, briquetting, laboratory and matte concentration. Labor is $5.44 per 24 hours, and coke $12.50 per ton. The cost of treatment per ton of 2,000 pounds is as follows: Mining $0.4938, or 10.1 per cent; removal of overburden* $0.4321, or 8.8 per cent; delivery of ore to works* $0.2619, or 5.3 per cent; sampling* $0.0393, or 0.8 per cent; smelting $2.3664, or 48.7 per cent; converting $0.3442, or 7.0 per cent; supervision $0.1259, or 2.6 per cent; disposal charges $0.7993, or 16.4 per cent; a total of $4.8638, or 99.7 per cent. The items marked with an asterisk * are those usually overlooked by the casual figures. Taxes, legal and administrative, are not included. The second example given by the author applies to the Tennessee Copper Co., where the ore is a pyrrhotite, containing about 2½ per cent of copper and traces of the precious metals. The analysis of the ore of the principal mine is as follows: Iron 38 per cent, sulphur 29 per cent, silica 11 per cent, lime 5.5 per cent, alumina 6 per cent, magnesia 1 per cent, maganese oxide 0.75 per cent. The ore is treated by pyritic smelting. Labor is $2.60 per 24 hours, and coke $3.50 to $6.00 per ton. The cost sheet for the treatment of a ton of 2,000 pounds is as follows: Mines development* $0.1712, or 5.6 per cent; mining, hoisting, etc., $0.6861, or 22.5 per cent; crushing and sorting* $0.1060, or 3.5 per cent; railway, delivery at works,* $0.1279, or 4.2 per cent; smelting $1.2450, or 40.9 per cent; converting $0.2313, or 7.6 per cent; engineering and laboratory* $0.0534, or 1.7 per cent; freight, insurance and selling expenses $0.2366, or 7.8 per cent; taxes and general expenses* $0.1809, or 5.9 per cent; a total of $3.0384, or 99.7 per cent. The third example refers to an ore in Mexico, 50 miles from a railway, the ore to be practically the same as in the first example, as far as gold, silver and the other constituents are concerned, and the method of treatment the same. With labor at $1.50, gold, per 24 hours, and coke at $30.00, gold, per ton, the cost of treatment per ton of 2,000 pounds would be as follows: Mine development* $0.40, or 8.6 per cent; mining* $1.00, or 21.4 per cent; delivery to works* $0.10, or 2.1 per cent; smelting $2.03, or 43.5 per cent; converting* $0.14, or 3 per cent; engineering and laboratory* $0.10, or 2.1 per cent; freight and disposal charges $0.89, or 19.1 per cent; a total of $4.66, or 99.8 per cent. The freight on blister copper is $30.00, gold, per ton. The disposal charges in these various cost sheets amount to 16.4, 7.8 and 19.1 per cent respectively. As the refining charges are rarely constant, the ratio between them is roughly in proportion to the amount that has to be paid for freight on the blister copper from the works to the refinery or market. Roughly, mining and smelting costs vary in proportion to the ordinary labor cost; the establishment of the correct cost of a few items will give a fair approximation of the whole; for the reason that, with the exception of coke, coal and stores, the mine and smelter consumes practically no raw material costing cash, but only material costing labor.

ANALYSIS OF CURRENT ELECTRO-CHEMICAL PATENTS.

Electric Furnace.

Iron Reduction in the Electric Furnace.—C. S. Bradley, 829,907, Aug. 28. Application filed July 31, 1903.

Lead and copper can be reduced by fusing together suitable proportions of their oxides and sulphides, the sulphur and oxygen combining to form sulphur dioxide, which passes off. If we want to employ the corresponding reaction in the case of iron, it is to be considered that the reaction between iron sulphide and iron oxide is endothermic and requires a large amount of heat. For this reason it is proposed to employ an electric furnace. As oxide, hematite or magnetite may be used; the carbonate may replace the oxide, since at the temperature in the electric furnace the carbonic acid gas passes off, leaving an oxide. As sulphide, pyrites or other sulphide ore or waste products may be used. The silica or other gangue associated with the ores is converted to a slag and the coalescence of the reduced metal facilitated by the addition of a suitable fluxing material, like limestone. The following example is given: Crushed hematite and pyrites are mixed in the proportion of, say two to one by weight, together with a flux, and raised in an electric furnace to a temperature considerably higher than is attained in the ordinary iron blast furnace, "probably in the neighborhood of 3,000° to 4,000° C., and possibly higher." After the mass has reached a molten condition, the current is increased, thereby raising the temperature. When the temperature of the reaction is attained the charge boils violently with copious evolution of fumes of SO_2, which pass off and may be collected. The iron collects at the bottom. The following two equations are given as representing the reactions:

$$FeS_2 + heat = FeS + S$$
$$3FeS + 2Fe_2O_3 = 7Fe + 3SO_2$$
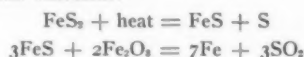
The process is said to be also applicable to the production of alloys, like chrome-iron by melting an oxide of chromium with a sulphide of iron.

Crucible for Induction Furnace.—E. A. Colby, 830,208, Sept. 4. Application filed Nov. 23, 1905.

To facilitate charging and discharging of the crucible, the crucible opening is enlarged by making its walls not truly cylindrical, the chamber surface of one wall being vertical and cylindrical, that of the other wall frusto-conical. In order to protect the crucible from rupture, due to the compressive strain of the material solidifying in the crucible, a lining is used of any refractory material which is more friable, and hence more easily crushed than the solid refractory material of the crucible itself, or if the lining is of the same refractory material as the crucible, it is in some way made less dense or less resistant to the compressive strain.

Electrolytic Processes.

Electrolytic Production of Copper.—J. A. W. Borchers, P. R. Franke, F. E. Günther, 830,639, Sept. 11. Application filed Sept. 21, 1906.

The object is the direct electrolytic treatment of copper matter. The inventors refer to former commercial trials as follows:

"In the experiments at Stolberg it was discovered that in the electrolysis in acid solutions of copper sulphate of the kinds of copper matte formerly employed by the coöperation of ferric sulphate, $Fe_2(SO_4)_3$, or of SO_4 ions from the sulphides forming the anode mass, sulphur was deposited on the surface of the anode and the metals passed into the solution at first readily, but subsequently only with the consumption of considerable electromotive force the copper was transferred from said anode onto the cathode. Now, we have discovered that the reasons

for this are as follows: To overcome the affinity between Cu_2S and FeS and other sulphides requires of itself a larger expenditure of power than was allowed for in the calculations of previous experimenters. The amount per unit of volume and the mechanical nature of the sulphur that is separated out of FeS (which is the metallic sulphide occurring in greater part as a subsidiary constituent in copper matte) and that of the sulphur separated out of Cu_2S are materially different, as a glance at the values of the molecular and atomic weights will show:

1. FeS (88) = Fe (56) + S (32).
2. Cu_2S (158) = Cu_2 (126) + S (32).

Thus for the same residual amount of sulphur there disappear in the process of solution fifty-six parts, by weight, of metal in the first case, and 126 parts, by weight, of metal in the second case—that is to say, one atom of metal in the first case and two atoms of metal in the second case. The greater the percentage of contained FeS the greater the quantity and the denser the nature of the sulphur that remains behind per unit of volume on the anode. The greater the amount of sulphur and the more densely it is deposited the more rapidly does the mechanical resistance against the access of the active constituents of the electrolyte to the anode mass which is still to be dissolved increase. The more slowly therefore the products of electrolysis formed on the still active surface of the anode are able to pass away so much easier substances which give rise to disturbing or costly electromotive counteractions are produced underneath the covering of sulphur, which prevents the equalization of concentration."

To overcome these disadvantages the inventors melt the copper matte to a degree of concentration of approximately 78 to 80 per cent of copper by means of the well-known reververberatory or converter furnaces, cast the mass into plates and electrolyze the latter as anodes in an electrolyte compound of acidulated aqueous solution of copper sulphate opposite to pure copper sheets as cathodes. Under these conditions the electrical pressure in the bath between anode and cathode is said to remain generally below 1.0 volt at ordinary temperature and with customary circulation of the electrolyte even after layers of sulphur of some thickness have been deposited. Whether and how often the layer of sulphur must be scraped off from the anode during electrolysis will depend chiefly on the local conditions. The sulphur may thus be recovered.

Electrodeposition of Metals; Copper Refining.—J. A. Nussbaum, 832,024, Sept. 25. Application filed Nov. 28, 1905. (Assigned to Siemens & Halske A. G.)

The object is to get metallic deposits in thick, dense, coherent layers, and to prevent objectionable crystal formations. The latter are said to be due to the fact that after the setting free of the metal ions the metallic separation does not at once follow, but an unstable intermediate form still remains for a short time in solution, from which metal deposits first here and there, where the conditions favorable to its separation exist—such, for instance, at those places where crystals already exist, which crystals will, therefore, grow larger at the expense of adjacent portions of the cathode, taking on a form of needles, foliations, etc. "If conditions be established in the electrolyte which hinder or prevent the changing of place of the unstable intermediate form before the separation as coherent metal, these will also restrain or prevent the formation of dendrites. This advantage will be secured by diminishing the movability of the electrolyte in the boundary zone at the cathode surface." For this purpose a slimy or colloidal substances of that class is added, which has the property of wandering to the cathode. In this way an intermediary colloidal layer is formed at those places on the cathode where crystal points tend to grow by the local shifting of the metal separation, which causes at these places a strong current density, as a result of which an in-

creased traveling of the colloids to those places occurs. "The colloidal layer acts as a diaphragm, since it checks diffusion and circulation. In the progress of the electrolysis these deposition centers shift from place to place, so that the process may be explained as a fluctuating diaphragm on the cathode." As particularly effective colloids are mentioned the seed mucilages (linseed, for example), roots or bulb mucilage (salep), vegetable gums, glutinous plant saps, albumen and their hydrolization and transformation products of animal and vegetable origin (glutin, condrin, mucin, etc.). It is claimed that by this method one is enabled to get good metal deposits from any salt solution, so that one is no longer restricted to certain salts, which are usually expensive. As an example, copper refining is mentioned, where copper sulphate is used, "notwithstanding that with the same current cuprous salts give double the yield of copper, since the electrochemical equivalent of the copper therein is twice as great. The reason why the cuprous salts—for example, copper chloride—have not been employed, is that the metal separates therefrom in present known processes in the form of crystals—that is, in a form most unsuited for technical purposes. By the employment of the above invention, however, a solid coherent crystalline deposit is obtained from a solution of copper chloride and sodium chloride. In this case it is sufficient to add to the solution about 0.2 per cent of a colloid which has the property of wandering to the cathode, for example, flax, or linseed mucilage or salep mucilage. The current density may be the same as in the present known process of copper refining, and also the content of the solution in copper may be the same as ordinarily employed."

Electrolytic Precipitation of Copper.—B. Comba, 820,555, May 15. Application filed Sept. 14, 1903.

The object is to precipitate copper from acid liquors containing it; for example, a solution of copper sulphate obtained by lixiviation of roasted copper pyrites or iron pyrites containing copper, by means of the substitution for the copper of another metal of less value, usually scrap-iron. This is done in a tank representing in principle a short-circuited double-fluid primary cell without diaphragm. Sheets of copper, or preferably lead, are suspended in the tank which is filled with the copper solution, and on these sheets the copper is deposited "in such a ductile condition as to be ready for rolling." On top of these sheets, and in electrical contact with them, a sheet of copper gauze is placed, upon which the scrap iron rests in a solution of slightly acidulated warm water. On account of its lower specific gravity, this solution remains on top above the heavier copper solution. The plane separating the acidulated water and the copper liquor gradually drops as the liquor deposits its copper and loses its color. Fresh copper liquor is then automatically introduced at the bottom.

Electrolysis of Zinc Sulphate.—V. Engelhardt, 831,843, Sept. 25. Application filed Sept. 14, 1904. (Assigned to Siemens & Halske A. G.)

The object is the production of a crystalline, dense, smooth, electrolytic zinc deposit, free from sponginess and roughness or irregularities of surface, by electrolysis of a zinc sulphate solution with insoluble anodes. This is accomplished by using an anodic current density of from twenty to fifty times that at the cathode. "Thus for practically obtainable zinc concentrations in which a current density at the cathode of about 150 amps. per square meter of the cathode surface is employed, the current density at the anode either for the whole surface or at single places of the same would be from 3,000 to 7,500 amps. per square meter of the surface." Either an anode of smaller dimensions is used or an anode of a surface equal to the cathode, but reinforced at several places, as, for example, by bands, ribs or wire insertions, so that at these places a high conductivity is produced, and therefore a higher current density obtained. The possibility of using an anode of very small dimensions permits the employment of platinum, which is advantageous, since it cannot foul the solution. The beneficial

effects of a high anodic current density are attributed to the fact that "the formation of ozone and super-sulphuric acid is materially promoted, and these have an oxidizing effect upon the cathode or zinc hydrogen."

Diaphragm.—I. L. Roberts, 831,474, Sept. 18. Application filed Dec. 23, 1904. (Assigned to Roberts Chemical Co.)

In Fig. 1 the cut or basket 1 of wire gauze is strengthened at top and bottom by metal rings 2, 3. Inside of the basket is a cloth bag or lining 4, within which is a layer of the "plastic or gelatinous material" 5. In setting up the cell, a layer 6 of the plastic material is first placed on the bottom of the cloth-
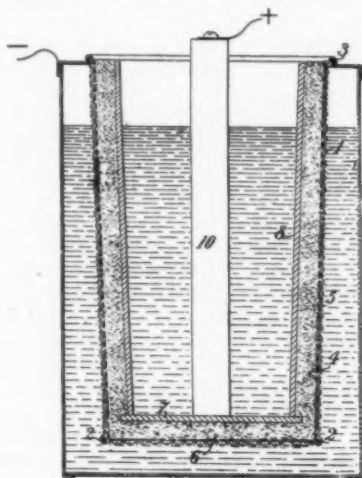

FIG. 1.—DIAPHRAGM.

lined basket, and then a disc 7 of a composition of asbestos and magnesium silicate (known commercially as "transite," "magnesia building lumber," etc.) is pressed upon the viscous material until the two are in close contact, leaving the gelatinous or viscous layer of the desired thickness, generally equal to or slightly greater than the space which separates the edge of the disc from the sides of the bag. On the disc is now placed a cylinder or tube 8, made of the same asbestos-magnesia composition, and the space between the cylinder and the bag is then evenly packed with plastic material.

Water Purifier.—F. R. Hinkson, 831,434, Sept. 18. Application filed Oct. 7, 1905.

"An electrolytic device for purifiers, comprising a plurality of closed compartments arranged in a vertical series, and adapted to successively receive the inflow-current of the fluid to be purified, said compartments being separated by bipolar electrodes and terminal electrodes adapted for connection to a source of current."

STORAGE BATTERIES.

Storage Battery Plate.—T. A. Edison, 831,269, Sept. 18. Application filed March 5, 1903.

In the well-known construction of the Edison battery the active nickel and iron masses are contained in pockets, and are maintained therein under pressure by means of closing plates, secured in place by overturning the metal around the edges of the pockets over upon the closing plates. The pockets, as well as the closing plates, are perforated. The plates are made of thick material (0.02 inch). For the purpose of economy in manufacture the perforations formed in the integral receptacles as well as in the closing plates are quite large, and the active material is prevented from exuding through these perforations by interposing very thin (0.0025 inch) sheets of nickel-plated material, and which are formed with extremely small perforations through which the active material cannot pass.

ELECTRIC DISCHARGES.

Chemical Effects in Gases.—D. R. Lovejoy, 829,876 and 829,877, Aug. 28. Application filed Jan. 27, 1903. (Assigned to Atmospheric Products Co.)

If union or chemical action of gases (like combination of oxygen and nitrogen) is to be accomplished by the agency of electric arcs, it is recommended to first subject the gases individually to the action of electrodes charged to a high electric potential, "in such a manner that the respective molecules of the two gases shall be given an electrostatic charge of high potential, the molecules of one gas being given a positive
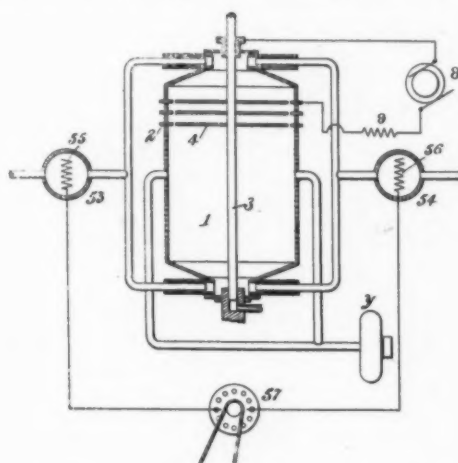

FIG. 2.—APPARATUS FOR TREATMENT OF GASES BY ELECTRIC DISCHARGES.

charge, and the molecules of the other gas a negative charge previous to subjecting the gases, after mixing the same, to the action of electric arcs." (See also the patent abstracted on page 371 of our September issue.) In Fig. 2 the two gases first pass through the electrifying chambers 53 and 54, containing electrodes 55 and 56, charged to high potentials of opposite polarity from 57. The electrostatically charged gases are then passed into chamber 1, where they are subjected to arc discharges between the fixed electrodes 2 and the movable electrodes 4; y is an exhaust fan. If equal volumes of oxygen and nitrogen are treated by this process, the electrodes 55 and 56 are charged to about 50,000 volts, while the limits of voltage maintained between the arc terminals 2 and 4 may be about 10,000 volts; for instance, with a current of 0.1 amp.

Production of Ammonia and Caustic Alkali.—G. E. Cassel, 830,299, Sept. 4. Application filed Aug. 22, 1904.

Electric discharges through air produce compounds of nitrogen and oxygen. By absorbing them by lime or carbonate of lime, nitrate and nitrite of lime are formed. These salts are subsequently treated with an alkali salt—for example, sulphate or chloride of an alkali—whereby a corresponding quantity of nitrate or nitrite of alkali is produced, which is subsequently subjected to electrolytic treatment with insoluble electrodes without diaphragm. In this electrolysis ammonia is produced, which passes off and is collected. The reduction, however, does not yield any appreciable output unless the solution contains a sufficient quantity of nitrites. In case of a deficiency, sufficient nitrites must be supplied, either by adding a suitable quantity of nitrites or a small quantity of a soluble salt of lead, for example, 0.5 per cent of nitrate of lead. These additions may be dispensed with, however, if a small cathodic current density is used, for example, not more than 1 amp. per square centimeter.

On account of limitations of space a number of abstracts of patents had to be reserved for our next issue.

RECENT METALLURGICAL PATENTS.

ZINC.

Retort Construction.—To prevent the destruction of the bottoms in the retorts in zinc-distillation processes, R. Fiesing (818,070, April 17, 1906) constructs the retort with a false bottom, affording a protective shield and a ventilating passage beneath the floor proper of the retort. This floor is further provided with longitudinal ribs, or ridges interiorly of the ventilating passage, designed to stiffen or strengthen the structure, and also increase the radiating surface for cooling the floor of the retort to avoid its deterioration or injury.

Refining Zinc.—J. Callman and R. Bormann (827,418, July 31) patent a continuous process for zinc refining, the characteristic feature being that the zinc is distilled while in a liquid condition and flowing in a thin stream through a pipe, which is heated by a regeneration method and fitted with discharge pipes for the zinc vapor. A pipe of refractory material is connected with a vessel containing the zinc to be refined in a molten condition. This pipe is slightly inclined, and opens either into a vessel intended for the reception of the impurities melted during the distilling process or into a retort, which is also somewhat inclined and heated. While the outflow of the molten zinc from the above-mentioned vessel into the pipe is regulated by suitable appliances in such a way that the fluid zinc passes on through the pipe in a thin stream or layer and only flows into it as it evaporates, the pipe is best maintained by regenerative heating at such a temperature that at the in-flow part it is only slightly hotter than the melting point of zinc. On the other hand, at the mouth of the pipe the temperature should exceed the boiling point of zinc. The fluid zinc is accordingly gradually brought to the boiling point and evaporated as it passes through the pipe. While the vapor is being condensed in condensing chambers, the foreign metals, in a more or less molten condition, pass into the receiving vessel at the end of the said pipe intended for them and from which they can be taken away. A retort or crucible may be fixed between the pipe and the last-mentioned receiving vessel, the heat supply being regulated in such a way that the boiling point of zinc will only be reached in the retort, to which also the zinc will flow in only small quantities. While the zinc vapors escape through the neck of the retort, the foreign metals flow off through an aperture close to the bottom of the retort into the receiving vessel. In order to insure as far as possible a perfect distribution in the pipe and retort of the zinc to be distilled, the latter are filled with pieces of fire-resisting or inert materials, such as fire-brick and the like. Instead of fire-resisting or inert materials pieces of coal may advantageously be used, as these combine with the oxygen in the pipe and prevent the zinc from being oxidized. On the other hand, however, if dregs of zinc containing oxygen are treated by this process the coal will abstract the oxygen from these dregs and also from the oxygenous foreign metals, so that the zinc as well as the foreign metals are obtained in a pure metallic condition.

Flux for Extracting Metals from Ores.—A patent of A. Gutensohn (826,568, July 24) refers to the treatment of ores holding metals in silicious combinations and tailings mixed with silicious impurities. The salient feature is the use of a flux, consisting of 1 part of borate of manganese, 1 part ground anthracite coal and 2 or 3 parts of fluor-spar, mixed with gas tar. The quantity of flux used is generally the estimated weight of the metal in the ore. It is stated that "this flux can be most advantageously used in the distillation of zinc out of ore, as it not only enables the metal to be obtained much quicker and at a lower heat than is now necessary, but prevents the usual rapid destruction of the retorts." In the treatment of poor ores or low-grade material the quantity of the flux equals the estimated weight of the metal in the ore, and the metal when reduced will form into globules in the slag, which is then chilled in water with or without a small quantity of sulphuric acid or alkali; the chilled mass is afterward dried and ground to powder, when the globules, in consequence of their high specific gravity against the other material, can be easily recovered by any of the usual concentrating methods.

SILVER AND GOLD.

Cyanide Process for Silver Extraction.—With reference to the developments at Guanajuato, Mexico, described in the article of Dr. J. W. Richards in our September issue, we noticed on page 371 two patents of F. J. Hobson on the treatment of silver ores by the cyanide process. A third patent (827,368, July 31) of the same inventor refers to the same subject, and may be best characterized by quoting claim 4: "As a selective solvent for silver when in combination with sulphur, a solution of potassium cyanide to which has been added mercurous chloride," and claim 6: "As a solvent for silver in the presence of sulphur, a solution of mercurous potassic cyanide, having the formula $KHgCy_2$, and of approximately 0.05 to 0.50 per cent in strength."

Cyanide Process.—C. W. Merrill (825,920, July 17) patents a modification of the cyanide process for treating that class of ores and tailings which contain reducing salts or minerals. After a preliminary treatment of the precious-metal-bearing material with a cyanogen-bearing solution, the latter is withdrawn from the interstitial spaces of the crushed material and a solution of chloride of calcium (which is obtainable, mixed with chloride of calcium, in the form of bleaching powder in sufficient quantities at low cost) is introduced into the interstitial spaces of the mass in the container, the effect of which is that such particles of reducing material as may be there present are oxidized. The hypochlorite solution is then displaced, and the particles within the container are subjected to further treatment with the cyanogen-bearing solution.

Slimes Treatment.—C. W. van Law (826,390, July 17), of Guanajuato, patents an apparatus for filtering slimes. A "slime-supply tank" contains a revolving agitating mechanism; from there the material flows to the "slime-pressure tank," until the latter has the desired amount of material stored therein to perform ore treating operation. The valve between both tanks is then closed, and air is admitted under pressure at the upper part of the slime-pressure tank, whereby the slimes are forced from the hopper-bottom of the slime-pressure tank through a pipe upwards into the hopper-bottom of the "filter tank." The latter is situated at a higher level, and contains a plurality of filtering frames of special construction, surrounded by wire-mesh and an enveloping canvass sack. These frames are placed side by side, but with free spaces between them, which spaces are gradually filled with cakes of the solid slime material, while the solution passes through the canvass into the frames and upwards through a pipe into a "recovery tank." There are also provided a "standard tank," containing cleansing water and a compressed air reservoir. A series of proper valves is, of course, provided in the pipes connecting the different tanks.

Separating Solution from Sand and Tailings.—W. H. Lomas, of Doornfontein, near Johannesburg, patents (825,331, July 10) an apparatus comprising an endless porous belt or band, which serves as the filtering medium upon which the solid matter is deposited and from which the separated solid matter is removed and collected. This belt or band is arranged to pass round a perforated suction-drum and round another perforated drum or pipe, from which a current of a fluid (gaseous or liquid) passes to displace or remove the deposited solid matter from the surface of the filtering belt. A suitable arrangement of guide and driving pulleys is provided for directing the belt over or round the greater portion of the circumference of the suction-drum. The suction-drum is arranged to run in a trough or tank in which the mixture of liquid and solid is placed, and the interior of the drum is coupled up or placed in connection with a pump, for creating a partial vacuum in the drum, so that the liquid portion of the mixture is thereby drawn through the interstices of the filtering

belt into the drum, from which it may be removed by the same or an additional pump. In the interior of the suction-drum is arranged a damper, which serves for preventing the ingress of air or liquid around that portion of the circumference of the drum which is not covered by the belt.

TIN.

Detinning.—In our August issue, page 325, we commented on a new chemical process by Dr. Karl Goldschmidt and Mr. Josef Weber for detinning tin scrap. This process was, in its general features, like a process of Mr. F. von Kügelgen and Mr. G. O. Seward (see our September issue, page 344), since both processes use a solution of chlorine in an anhydrous liquid. Essentially different is a new process of Dr. Karl Goldschmidt and Mr. Josef Weber (831,223, Sept. 18), in which no anhydrous liquid is used. Its essential features consist in subjecting the tin scraps in a firmly compressed state in a closed vessel to the action of chlorine gas, and in altering the pressure in the vessel when the reaction of the chlorine on the scraps takes place. The chlorine gas is not employed in a pure state, but mixed with neutral or inert gases, like dry air. It is of importance to avoid in the process high temperatures in the mass of the tin scraps and to use the tin scraps in a well-dried state. The bundles are compressed, and of such a size that they can afterwards be directly used in steel works. They may conveniently be 40 centimeters wide, 60 centimeters long, and 8/14 centimeter high, the weight being about 50 to 60 kilograms. The packets are placed in baskets, which are put into the vessel. The process is so guided that the pressure in the vessel is increased, so that at the end of the operation the over-pressure—for instance, of one atmosphere above the ordinary pressure—is obtained. By the increased pressure of the vessel the chlorine gas comes in contact with all the surfaces of the tin scraps, so that even between the most closely packed surfaces of the tin scraps a sufficient action of the chlorine gas and formation of chloride of tin takes place. The iron waste remains perfectly detinned and with a fine, smooth gray surface. The process would seem to be of ideal simplicity for large-scale operation, when the mechanical difficulties of handling dry compressed chlorine gas are overcome. But it is known that such difficulties have been completely overcome in various European plants.

BOOK REVIEWS.

THE MANAGEMENT OF ELECTRICAL MACHINERY. By Prof. Francis B. Crocker, Ph. D., and Schuyler S. Wheeler, D. Sc. 223 pages, 131 illustrations. New York: D. Van Nostrand Co. Price, $1.00 net.

This excellent little book, which here appears in its second edition, is intended to give simple directions for the practical use and management of dynamos and motors. It is a thoroughly practical book, and it is remarkable what an enormous amount of useful information is here given in a comparatively small space.

The book is divided into five parts. The first deals with the selection and management of dynamo-electric machinery (principles of generators and motors, selection, installation, connections, operation). The second part deals with inspecting and testing (adjustment, friction, balance, noise, heating and sparking, measurement of resistance, voltage and current, speed and torque, power and efficiency). The third part, which should be greatly appreciated in practice, gives concise instructions as to the localization and remedy of troubles. The fourth and fifth part deal with constant-current (arc) generators and with railway motors, respectively.

NOTES ON METALLURGICAL MILL CONSTRUCTION. Edited by W. R. Ingalls. New York: *The Engineering and Mining Journal.* 256 pages. Price, $1.50.

The book, the price of which is remarkably low, is a reprint of a series of articles bearing upon the following seven general subjects: Brickwork and concrete, building construction, ore-crushing machinery, driers and drying, conveyors and elevators, disposal of tailings, miscellaneous.

The articles reprinted here have formerly appeared in *The Engineering and Mining Journal,* chiefly during the last three years. The book is, therefore, of a somewhat heterogeneous character, and in the nature of a scrapbook rather than a general complete treatise. But this has some decided advantages, especially since the individuality of the different authors has been preserved. A scrapbook is a most useful thing, if made up in the right way, and the editor of the present volume is to be congratulated on the excellent judgment he has shown in its preparation.

A New Canadian Custom Smelter.

BY MARTIN W. PESCHEL.

During my presence in the northern parts of the provinces of Ontario and Quebec, I often spoke with mine owners and prospectors concerning the necessity and possibility of a smelting plant that would not only treat those exceptionally high-grade ores mined directly at and around Cobalt, but would also enable the miner of a more distant locality and mining a lower grade of ore, to dispose of his mine products at its market values without having to carry the burden of a freight rate of $9.00 per ton from Cobalt to New Jersey.

If one considers that the New Jersey smelters only treated the higher grade of ores, which were often penalized in an unjustified way, the poor and independent miner's outlook into the future could not be called very bright. Several schemes had been considered to overcome this great drawback, and a smelter was indeed planned. The reasons why such an enterprise, with such great prospects, did not realize, are unknown, although it was generally believed that the heavy treatment expenses of the cobalt-nickel ores would render profits too doubtful, while the amount of ore mined at the time was still too small to supply a smelter of even a moderate capacity sufficiently.

The latter reason for the failure of the erection of a reduction work might have been justified as far as the cobalt-silver ores of the township of Coleman are concerned. But as the Canadian mining regions of Ontario and Quebec are more or less in their infancy, and the mineral wealth of these provinces not confined to the township of Coleman, a broad-minded enterprising smelterman would have thought of the vast area these two provinces do cover on the maps of Canada.

There is beside those rich mines an abundance of calcspar-veins assaying from 5 to 200 ounces of silver per ton, and it is well known how easy those ores can be treated by simply adding them to the charge of a lead or copper furnace. Whether such ores would allow a freight rate of $9.00 per ton is another question, but they certainly could be disposed of if a smelter would be near at hand. Lately discoveries of big copper deposits with fair values of the precious metals have been made in the Temagami Forest Reserve, and further reports of discoveries of all kinds of ores are made continually.

On my return trip to North Bay I learned that a smelter at Front Lake, 3 miles distant from the town of North Bay, was in course of erection, but people had previously paid attention to various rumors which had not realized, and did not seem to take much stock in the "little active work" commenced outside of their town, and spoke of a "bluff." What I found at Front Lake, however, could no longer be called a bluff.

Long concrete foundations and walls had already been erected, with a large gang of men employed in grading, etc., for further buildings. The plan shown to me in the company's office spoke for itself, as well as the name of the designer, and that the Canadian Government fully realizes the necessity of

an independent custom smelter was proved by the support it has given from the very start to the project.

Mr. J. H. Brown is the organizer of the Montreal Reduction & Smelting Co., of Canada, Ltd., and the designer of the plant. All the members of the syndicate, with the exception of Mr. J. H. Brown himself, are prominent Canadians, and the at-
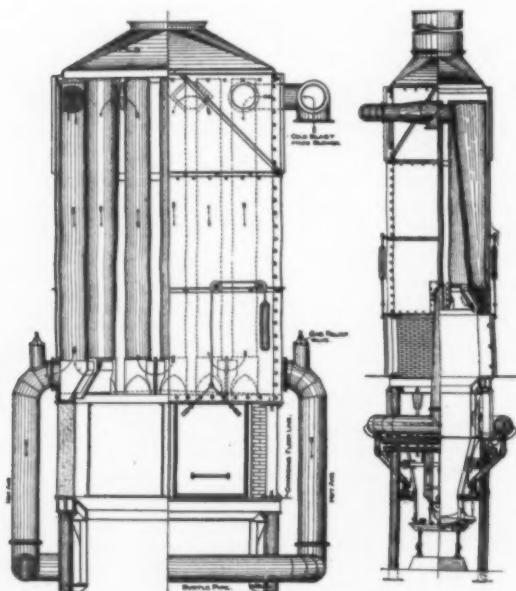

FIG. I.—DIAGRAMMATICAL SKETCH OF GIROUX HOT-BLAST FURNACE.

tendance at the ceremony of the laying of the cornerstone, which took place on Sept. 10, showed clearly how highly the population of Canada is welcoming the new enterprise.

There are plenty of men all over the world who can stumble over a rich ore vein, but there are only a few who can design and superintend a custom smelter of the kind they are in need of here, if the success hoped for shall not turn into failure.

It is intended to commence operations this year. The plant will have a daily capacity of 500 tons, and will treat all kinds of ores by concentrating, smelting, amalgamating, converting, cyaniding, etc., and will be up to date in its equipment.

The cornerstone was laid by the Minister of Mines of the Province of Ontario, amid the cheers of 3,000 onlookers, and in the presence of the Minister of Agriculture, Hon. Montieth, and the whole Board of Directors. The meeting was presided over by the Mayor of North Bay, who read an address, to which the Minister of Mines replied, pointing out the progress which the Western States had made since the erection of smelters. Mr. Leonard, M. P., and president of the company, presented then the deed to the company. Hon. Montieth spoke similarly, recalling the memory of Champlain, who had traveled through this part of the country on his voyages. Mr. Monk, M. P., made an eloquent speech, as the representative of the company, and Mr. J. H. Brown made the final address, stating that the plant would be the most up to date and complete.

It is to be hoped, according to the way the Canadian people and Government have supported the enterprise so far, that this plant will be to Eastern Canada what the great custom smelters are for the West. The facilities which it has, both by water and rail, are excellent, and all conditions are in favor of the new enterprise, which, as a Canadian concern, but promoted and guided by an experienced American, will give employment to at least a thousand men.

Hot-Blast Smelting.

The National Metallurgical Co., of Matehuala, Mexico, is almost ready to put into service a new blast furnace, designed and built by the Traylor Engineering Co., of New York City. The furnace measures 42 inches by 160 inches inside the tuyeres, and will add 250 to 300 tons per day to the capacity of the plant.

One of the most interesting features of the construction of this furnace is that it is fitted with the Giroux hot-blast top. This top was invented by Joseph L. Giroux when he was manager of the United Verde Works, at Jerome, Ariz. This hot-blast system has been in use in the United Verde smelter for three years, and has there proved a great source of fuel economy, besides showing that the design is entirely successful in resisting the destructive effects of expansion and contraction, which has made other designs too expensive in maintenance. They have cost practically nothing for repairs. The tops are also in regular use at the works of the Giroux Consolidated Mines, in Ely, Nev. The top furnishes a blast heated to 400 to 500 degrees F.

Experience has shown that the new hot-blast top system gives a saving of 30 per cent of the fuel charge with some ores, while at the same time it increases the capacity of the furnace from 15 to 25 per cent. It allows the use of charges carrying from 2 to 4 per cent more silica, and the more uni-

FIG. 2.—END VIEW OF FURNACE WITHOUT HOUSING.

form temperature seems to prevent, to a considerable extent, the crusting or building up of the walls of the furnace, so noticeable in ordinary practice.

The Giroux hot-blast top is applied with advantage and economy to copper smelting furnaces where the process is largely oxidizing, and, as a result, the zone of heat is carried to a comparatively high line in the furnace.

The heat thus produced, instead of being wasted, is utilized for heating the blast. This not only makes a corresponding reduction in the amount and cost of the coke charge, but gives all the other advantages which are incident to the use

of the hot blast. For use where fuel is low in price, and a very hot blast is desirable, the Traylor Engineering Co. furnish a hot-blast stove, of a superior character, of its own design.

The Giroux hot-blast top consists mechanically of two series of metal pipes arranged symmetrically around the inside of the top of the furnace, the lower ends of the pipes being just above the top of the charging floor. The vertical portion of the pipes is built of sheet steel. These are circular at the bottom where they join the return elbows, and oval and of larger section at the top. The material of the pipes makes them readily permeable to the heat, and their form gives them a large surface for absorbing the heat from the
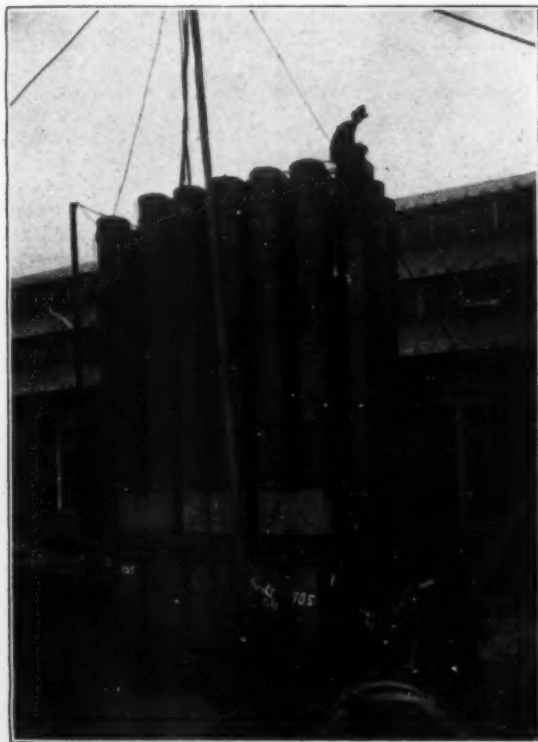

FIG. 3.—SIDE VIEW OF FURNACE WITHOUT HOUSING.

furnace gases. This form also prevents dust from adhering to them and reducing their capacity for absorbing heat.

Near their tops the pipes are connected together in pairs sidewise by means of flanged cast-iron connections, and at the bottom each pair of pipes is connected to form a continuous series on each side of the furnace by means of cast-iron return elbows. These elbows have a V-shaped section, with one side of the V lying parallel with the side of the furnace top, and the other forming a slope for the hot furnace to impinge against.

Cast iron is used for the elbows because it is the best material to resist the destructive action of the impinging furnace gases. The form of the elbows insures the delivery of the hot gases, and its distribution along the sides of the upright pipes in the best manner to insure their giving up of their heat to the blast air passing through the pipes. The attachment is built so that it may be used on furnaces with either sheet metal or brick tops, but the use of the brick top is always recommended. The brick is best because it is a good non-conductor of heat and thus concentrates the heat of the furnace in the air pipes.

The blast from the blower enters the furnace at the top of the attachment at the two ends. It then circulates through

the air-heating pipes in series, after traversing their length, passes down through the hot-air connection into the bustle pipe of the furnace, and from thence through the blow-pipes to the tuyeres. This top is mechanically perfect. There is no distortion produced by the heat, as all of the heating pipes are entirely surrounded by the furnace gases, and the expansion is, therefore, uniform throughout their length. This prevents the distortion from heat which has made other arrangements intended for this purpose failures.

A similar hot-blast attachment is now being constructed by the Traylor Engineering Co. for a furnace, 46 inches by 255 inches, under construction for the Dominion Copper Co., of Canada. This furnace will be the largest ever built.

Fig. 1 shows diagrammatically the general arrangement of the hot-blast furnace, while Figs. 2 to 4 give views of the hot-blast furnace for the Matehuala Works of the National Metallurgical Co. The photographs were taken in the erection yards at the works of the Traylor Engineering Co. in Allentown, Pa.

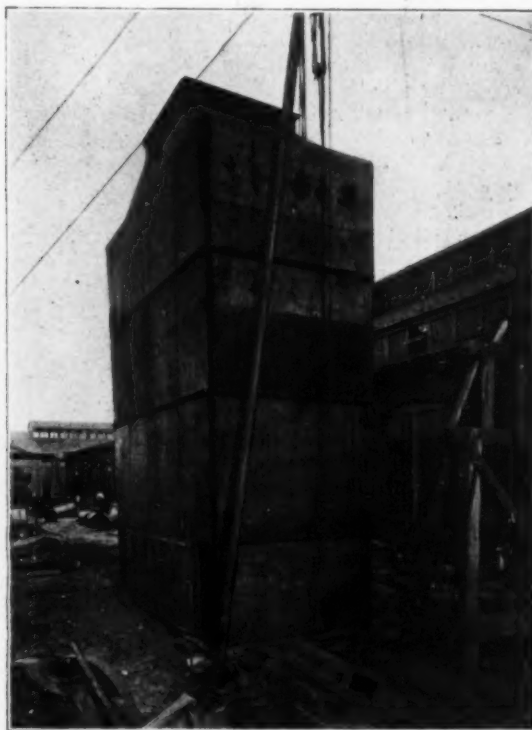Fig. 2 is an end view without housing, showing the blast

FIG. 4.—FURNACE COMPLETE WITH HOUSING.

connection at the upper left-hand side of the top, and bustle-pipe connection at the lower right-hand side.

Fig. 3 is a view without housing, showing the furnace charging doors under one set of side pipes, and the V-shaped form of the cast-iron bottom connection for the pipes.

Fig. 4 is a view of the complete furnace with housing.

Lime Burning in Rotary Kilns.—The Pittsburg Reduction Co. will soon be burning lime in rotary gas-fired kilns. The capacity of the plant will be 350 tons in 24 hours. Before deciding on rotary cylinders a trip was made to the New York Lime Co's plant at Natural Bridge, N. Y., which is the first plant to successfully burn lime in rotary kilns. The gas producer equipment is being supplied by the Morgan Construction Co., of New York. Besides 8 producers for heating 5 rotary kilns for burning lime and generating CO_2, 8 other producers are used for heating 6 rotary kilns for calcining bauxite.

Notes.

Historical Development of General Chemistry.—The July issue of the *School of Mines Quarterly* contains the concluding instalment of the series of lectures held by Prof. William Ostwald in the beginning of this year at Columbia University. This instalment contains the fifth lecture on equilibrium and chemical affinity and the sixth lecture on chemical dynamics, including catalysis.

The Goldschmidt Thermit Co. are about to vacate their present manufacturing premises at 179 Christopher Street, New York City, as they are insufficient for the largely increased business. They have bought ground at the corner of Cornelison and Bishop Streets, in Jersey City, and have erected there a large and commodious factory building, 165 x 75 feet, within easy reach of their down-town offices, and intend removing their manufacturing plant to the new location on or about Oct. 1.

Filter Presses.—Messrs. T. Shriver & Co., manufacturers of filter presses, have received one of the largest orders for presses ever given for installation at a single plant. The order is placed by the Pittsburg Reduction Co., and calls for forty-five large presses for use in their East St. Louis works.

Muspratt Laboratory.—The new laboratory of physical chemistry and electrochemistry, which has been presented to the University of Liverpool by Mr. E. K. Muspratt, will be opened by Sir William Ramsay, F. R. S., on Oct. 13, when a large number of English and Continental men of science will be present. Addresses will be made by Sir William Ramsay and Prof. Ostwald. A complete electrical equipment has been provided, including a 30-kw. motor alternator, a 30-kw. continuous-current motor generator, and a 10-kw. set for battery charging. The battery is composed of thirty-six Tudor cells. The new laboratory, which contains in all twenty-one rooms, is to be known as the Muspratt Laboratory of Physical and Electrochemistry, and is under the charge of Prof. Donnan.

Attack of Glass Vessels by Chemical Solutions.—In last year's report of the German Reichsanstalt, reference is made to the suitability of quartz vessels for chemical operations, and the absorption of water by glass exposed to the action of the atmosphere and, particularly, of the sulphuric acid of accumulators. This absorption of water is accompanied by changes in the composition of the glass, consisting essentially in the loss of potash and soda; the water is absorbed by the silica, which undergoes molecular changes. When the glass is slowly heated most of the absorbed water is given off a little above 100° C., the rest at 500°, and the glass peels. When the heating is rapid the water escapes in very small bubbles between 400° and 500° C., and the glass does not peel, but turns white like porcelain. One kind of glass for accumulator containers had absorbed 5.8 per cent of water in fifteen years. For good accumulator glass the effect is not of importance.

Turbo Blowers.—In a paper recently presented at a meeting of the British Association for the Advancement of Science, by Gerald Stoney, the author described the development of the steam turbine for driving rotary air compressors of the turbine type, which are now being used largely for blowing blast furnaces. The advantages gained are light weight, small foundation, small consumption of oil and, above all, high economy of steam over the reciprocating types of blowing engines. The outfits described are generally for about 20,000 cubic feet of free air per minute and a pressure of 10 to 15 pounds per square inch. A slightly different type is made for about 30,000 cubic feet per minute, at about 1 pound per square inch pressure. These blowing equipments are being used in several large iron works for dealing with the waste gases from furnaces and for driving these gases through the recovering plant, etc., an important feature being that they do not clog with tar and other matters. Since it is nearly impossible to use economically low-pressure steam at about atmospheric pressure

in a reciprocating engine, the exhaust steam turbine becomes an important factor in those cases where there are non-condensing engines and other sources of exhaust steam. The American rights for the manufacture of Parsons turbine blowers, as well as Parsons land and marine turbines, have been secured by the Allis-Chalmers Co., of Milwaukee, and through an arrangement made with the English builders, the American company will have the benefit of the experience and data of the European experts.

Gold from the Sea.—With respect to this problem, which has been in the past a source of income to a few promoters, and only to them, the London *Electrician* writes as follows: "Recently nothing has been heard of the Electrolytic Marine Salts Co., U. S. A., which was floated for the purpose of extracting wealth in the form of gold from the sea. But in a recent issue of *L'Electricien*, Mr. A. Nodon returns to the subject, and gives his views as to how this desirable object might be attained. He proposes to use copper or lead cathodes, preferably lead on account of the expense, sheets 1 mm. in thickness being suitable. These electrodes would be surrounded by canvas or other suitable material, forming porous bags, in which any deposit not adhering to the electrodes would be collected. The anodes could be made of graphite, lead or cast iron. Of these, however, graphite would be expensive and lead would be attacked, so that gray cast iron would be the most suitable from the chemical point of view as well as that of cost. The electrolytic baths would be in the seashore, within reach of the tide, and would have a depth of 2 meters and a breadth of 10 meters. By having cement partitions every 40 meters, a battery of 100 such baths could be run together, and would furnish 150 grams of gold per day of 12 hours. During this time 3,000 cubic meters of water would be treated, and a current of 5,000 amps. at 2.5 volts would be required. Mr. Nodon puts the annual cost at $12,000 and the profit at $20,000, with a capital of $40,000, the value of the gold recovered being taken at 60 cents per gram, so as to allow of subsequent treatment."

American Electrochemical Society.—At the September meeting of the Board of Directors, Mr. H. J. Wolf, of Telluride, Col., was elected a member, while at the October meeting the names of the following gentlemen will come up for election: Messrs. Frank A. Decker, Albert J. Shinn and William P. Divine, all of Philadelphia, Pa.

Illinois State Geological Survey.—We have received Bulletins Nos. 1 and 2 of the Illinois State Geological Survey. Bulletin No. 1 is a geological map of Illinois by Dr. Stuart Weller; it is very neatly executed in different colors, and represents the best information available at this time, and should, therefore, serve as an excellent base for future work. In Bulletin No. 2 Prof. W. S. Blatchley gives a review of the petroleum industry of Southeastern Illinois.

Progress of Krupp Works.—According to Consul-General Guenther, the celebrated works of Krupp, at Essen, Magdeburg, Kiel, Annen, and at their ore and coal mines had, on April 1, 1906, in their employ 62,553 persons, of whom 5,065 were officials and clerks, against a total of 55,816 employees in the year before. The company's principal plant and accessories at Essen consumed as much water in said year as did the entire city of Dresden, which latter has a population of over 400,000 inhabitants. The gas made and consumed by the single cast-steel plant at Essen exceeds the gas consumption of the city of Elberfeld. Besides this, the electric plant of these steel works supplies 1,651 arc lamps, 15,304 incandescent lamps and 763 electric motors. The average daily wage paid in 1905 to the workers in the cast-steel plant was $1.22 per person, which is about 5½ cents more than was paid in the preceding year.

Portland Cement Industry.—The Portland cement industry in this country presents one of the most marvelous instances of growth on record, showing the amazing increase in the output in the United States from 42,000 barrels in 1880 to 35,000,-

ooo barrels in 1905, or over 800 times as much, whereas in pig iron production the output in 1905 was only about six times that of 1880. This marvelous growth of the cement industry, however, has in no way interfered with the growth of the iron industry. On the contrary, cement has come as an auxiliary to help maintain the vast building activity and prevent an iron and steel famine. It has also relieved the lumber situation through its use in many forms of construction where timber would otherwise have been essential.. Many plants have sprung up within the last few years in various parts of this country, whose capacities run up into thousands of barrels daily. Contracts for cement-making machinery calling for an expenditure of hundreds of thousands of dollars are of frequent occurrence to the large cement machinery manufacturers. What is said to constitute the largest individual order ever placed for tube mills for the grinding of cement clinker is one recently placed by the United States Steel Corporation. This order calls for forty-seven tube mills, 5 feet in diameter by 22 feet in length. Twenty of these are to be installed in the plant of the Carnegie Steel Co., at Homestead, Pa., and twenty-seven are for an extension to the immense modern cement plant of the Illinois Steel Co., at Buffington, Ind. This entire order was awarded to the Power & Mining Machinery Co., Cudahy, Wis.

Gas Producers for Steel Plant.—Manufacturers have lately been stirred up by the largest contract for gas producers that has ever been given. Last week the Illinois Steel Co. closed for 140 large producers with gas flues and Dyblie reversing valves, to operate the twenty-eight open-hearth furnaces to be erected at Gary, Ind., constituting the largest steel plant in the world. For the past four months eight of the leading manufacturers in that line of business have been engaged in this contest, because of its great importance, not only on account of the large amount of work, but principally on account of the standing to be obtained by the successful type. A committee of engineers was appointed by the Steel Corporation to visit the various plants, investigate the claims and note actual results. The first approach to a decision came when the committee visited the plant of the Lackawanna Steel Co., at Buffalo, where they saw several of the leading types of gas producer in operation. The open-hearth furnaces, which are fired with gas from continuous gas producers having mechanical feeds, at that plant, are now turning out more steel with less coal consumption than any other plant in the world. When the order was placed the award fell to the Morgan Construction Co., of Worcester, Mass., who were represented in the contest by Mr. E. A. W. Jefferies, of 40 Exchange Place, New York City. This makes the fifth order for gas producers that the Illinois Steel Co. have awarded to the Morgan Construction Co. This company has also obtained a remarkable recognition of the merit of their work in England and continental Europe, where about 100 Morgan continuous gas producers have been sold during the past twelve months, this being the only American gas producer which has successfully invaded that field.

Tube Mill in Cyanide Practice.—Based on the results obtained from the operation of an experimental plant of half a ton capacity at Bodie, Cal., the Standard Mine designed a plant to which all the tailing from the Standard Mill might be applied in accordance with the Moore methods of treatment (which was described and illustrated in our Vol. III., p. 257). The new plant, which was placed in regular operation in 1905, has fulfilled the expectations of those who were responsible for its design. The ore at Bodie consists of quartz, iron oxides and clay. The gold is partly coarse and partly very fine, which amalgamates badly. The ore is difficult to treat in spite of the absence of all minerals ordinarily classed as deleterious. An Allis-Chalmers 5-foot x 22-foot tube mill does the regrinding. The under flow of two cone separators furnishes the feed. It contains the coarse stuff and a certain portion of adhering slime, and passes to the tube mill mixed with sand from the ponds fed into the stream automatically. The outflow from the mill is returned to the cones. The tube mill, which makes 26 r. p. m., is charged with 12 tons of pebbles at Greenland flints. Wrought iron plates are used for liners. They are 7/8 inch x 8 inches, and cut into 7-foot and 15-foot lengths, bolted through the shell. The power for the mill is approximately 50 hp. when running, and 100 hp. at starting. The grinding capacity is placed at 60 tons of sand per 24 hours.

Personal.

Dr. KARL GOLDSCHMIDT, partner of the firm of Theodor Goldschmidt, Essen-Ruhr, Germany, equally distinguished by their decisive pioneer work in detinning as by the aluminothermic process, is at present in this country. Some notes on the latest work of Dr. Karl Goldschmidt on detinning by means of chlorine gas, will be found in this issue, under the head of "Recent Metallurgical Patents."

Sir WILLIAM HENRY PERKIN, the famous inventor of mauve, arrived in this country on Sept. 30, to attend the celebration to be given by the chemists of the United States in his honor on the fiftieth anniversary of the coal-tar industry. The program of the celebration will be found on another page. The distinguished chemist will be the guest of Prof. C. F. Chandler during his stay here. On Oct. 1, Sir William will be the guest of Mr. George F. Kunz, the gem expert of Tiffany & Co. He will be escorted through various places of interest to chemists and the Museum of Art, the New York Botanical Garden and the Zoological Park will also be visited. On Oct. 2 the host will be Comptroller Metz, who is interested in one of the great German coal-tar firms. On Oct. 4, Sir William and his family will be the guests of Mr. H. H. Rogers, on whose yacht they will take a trip up the Hudson, while on Oct. 5 Sir William will visit the Laurel Hill Chemical Works, on Long Island, as the guest of Dr. William H. Nichols, President of the General Chemical Co. and the Nichols Copper Co., and Past-President of the Society of Chemical Industry. According to an interview, published in the New York *Times*, the distinguished inventor made the following statements to the reporter: "I was in the laboratory of the German chemist, A. W. Hofmann, when I discovered mauve. I was then 18. While in an experiment to find quinine I failed, and was about to throw a certain black residue away when I thought it might be interesting. The solution of it resulted in a strangely beautiful color. You know the rest. * * * * It is impossible, of course, for America to be ahead at the present moment in the matter of organic chemistry, in which I am especially interested. Germany has so many advantages, primarily cheaper labor. Besides that, German chemical manufacturers have established laboratories in which they place university graduates, whose business is nothing but to experiment and discover new things. This country, however, has greater opportunities for the future, as it is building its genius upon the genius of European centuries." When told that in the recent pure-food discussion the question of the possible injuriousness of aniline dyes in foods had been raised, he replied, "I would not like to take sides in that matter. It is probable that there have been abuses of the uses of aniline dyes in foodstuffs; in fact, I know there have been. But this is certain, that the amount of aniline dye necessary to color a food is so minute that if the same quantity of strychnine were used, it would be equally harmless."

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

OZONE.

No. 574,341, Dec. 29, 1896, M. Pridham, Philadelphia, Pa. Oxygen is cooled by passing it through a spiral coil, sur-

rounded by a refrigerating liquid, such as ammonium nitrate and water, or by compressing and expanding it, and then ozonized. The ozonizer comprises concentric tubes carrying electrode coatings. The outer tube is of glass, closed at the ends with caps having gas inlet and outlet pipes. The inner tube may be of a dielectric, but is preferably of metal, closed at the ends. A spray pipe for the cooling liquid enters through a central stuffing-box at one end and a waste pine leads from the other end. The outer surfaces of both the inner and outer tubes are coated with a rough or granular layer of material adapted to produce a brush-discharge, such as powdered carbon or lead dust, held by an adhesive non-conductor. The ozonizer is preferably worked at temperatures below zero degree F.

No. 577,523, Feb. 23, 1897, G. J. Anderson and J. C. Dittrich, Brooklyn, N. Y.

Ozonizes oxygen or air. The oxygen, produced by heating potassium chlorate and manganese dioxide, is passed through wash-bottles containing solutions of caustic alkali, sodium hyposulfite and sulfuric acid, to remove carbon dioxide, chlorine and water. The ozonized oxygen is employed to saturate distilled and sterilized water for medical use, or vegetable or mineral fats or oils. The ozonized air is passed into an alkaline solution or water, to produce nitric salts or acid. The ozonizer consists of four Siemens ozone tubes, having a single supply and discharge pipe, supported in a glass jar. The inner tube of each ozonizer is filled with water, into which dips one terminal. The jar is also filled with liquid.

No. 577,636, Feb. 23, 1897, E. Andreoli, London, England.

The electrodes are vertically arranged in horizontal series, within a casing having a bottom inlet and a lateral top outlet, resting on a slitted false bottom. The electrodes consist of thin metallic boxes spaced apart from intermediate dielectric sheets by means of glass blocks. The opposing faces of the boxes may be provided with serrated metallic strips. Water is circulated through the boxes by separate reservoirs and supply and discharge pipes. Air entering the casing-inlet is distributed to the slits in the bottom by a baffle-plate or fan.

No. 580,244, April 6, 1897, C. J. Yarnold, London, England.

The air to be ozonized is purified by passing it through a caustic alkali bath, then dried and cooled to 32° F. The ozonized gas is passed through a vessel containing pumice and water, to remove the nitrogen oxides. The ozonizer has electrodes, each consisting of two sheets of corrugated glass inclosing a layer of silver foil. The foil sheets have tabs, which are connected to metal rods in insulating sleeves. The electrodes are supported vertically in horizontal series on the floor of a casing, their lower edges being separated by ribs and their upper edges by depending fingers. The casing has a hinged cover with a window, and expansion chambers at each end, receiving the supply and discharge pipes. A thermometer enters each expansion chamber.

No. 587,770, Aug. 10, 1897, N. Vander Sleen and A. Schneller, Alfen-Oudshoorn, Netherlands.

Employs several ozonizers arranged in line, connected by intermediate parallel cooling pipes surrounded by water. The electrode plates of each ozonizer are hung from frames above. The electric potential is regulated by a resistance column of distilled water, glycerine or dilute alcohol, interposed in the circuit of each electrode. For a potential of 60,000 volts and a distance of 50 millimeters between the electrodes the resistance should be 20 megohms.

No. 596,936, Jan. 4, 1898, F. K. Irving, Passaic, N. J.

Generates ozone by electrolyzing a solution of copper or zinc sulfate with electrodes of an alloy of lead and antimony. The electrolytic cell is provided with an inhaling tube.

No. 597,517, Jan. 18, 1898, A. Verley, Paris, France.

The ozonizer comprises a horizontal rectangular sheet of copper, carried by a slate table and a rectangular sheet of silvered glass, distance pieces being interposed. Glass rods may be arranged between the two plates to provide a spiral or zigzag passage, air entering at the edge and the ozone escaping through a hole at the center. The slate and copper may be above the glass, the slate then being recessed to allow a current of water to circulate over it. Or the silvered glass may be arranged over the copper and slate. The ozonizer may be cooled by the expansion of compressed air. The potential difference is 5,000 to 12,000 volts, a direct current being employed.

No. 599,455, Feb. 22, 1898, M. Otto, Paris, France.

Employs electrodes, one of which rotates. The electrodes may be flat parallel discs or concentric tubes, one of which is provided with a series of discharging points or brushes of platinum or aluminium. The outer electrode or electrodes have re-entrant portions provided with external heat-radiating wings. In the disc form the electrodes are vertical, the intermediate one being carried by a horizontal shaft. The discharge points are arranged in sectors. The air is introduced at the center through a rose and passes radially. In the form using concentric electrodes, brushes projecting from the surface of the inner cylinder are arranged in two helical series partially separated by a disc projecting from the outer electrode casing. The apparatus may be of cast or sheet iron, or of a non-conductor, such as wood or porcelain covered with metal. It may be protected by a coating of platinum, gold, varnish or enamel. The potential difference with an electrode distance of 3 centimeters may be 18,000 volts. The apparatus may be used for the production of hydrocyanic acid from a mixture of nitrogen and acetylene.

No. 607,007, July 12, 1898, E. Andreoli, London, England.

The electrodes are opposing grids bearing points, or grids facing flat electrodes. The grids consist of pieces of serrated wire, separated by washers and bolted together. The flat electrodes are boards of hardwood, covered with thin sheets of copper, tin-plate, aluminium or an electro-plated metal. They may be coated with paint or enamel. One or two sheets of glass may be interposed between each pair of electrodes, or, in the case of flat electrodes, their face may be coated with pieces of mica or a layer of powdered mica held by an adhesive. The glass plates are placed in grooves in the casing. The air in larger rooms may be ozonized by using a number of separate ozonizers without casings. Concentrated ozone may be produced by employing several ozonizers in series.

No. 614,500, Nov. 22, 1898, A. S. Ramage, Cleveland, Ohio.

The electrodes, arranged horizontally in a casing having end pipes, each consist of a sheet of corrugated or pitted tin foil, cemented between two plates of glass by shellac. The electrodes are spaced by marginal glass strips, and are arranged in a casing consisting of a wood box having an inner layer of plaster of paris faced with glass.

No. 632,391, Sept. 5, 1899, H. Abraham and L. Marmier, Paris, France.

The electrodes are circular, vertical, metallic discs, with an inert coating of paraffin, silicate, red lead or enamel. The discs are hollow and provided with pipes for circulating water through them. To avoid short circuiting, the water is supplied and discharged in separate drops, or is intermittently passed from one insulated reservoir to another by siphons. The electrodes are centrally apertured and receive a perforated ozone discharge pipe. Each electrode is hung from an insulating cross-bar above. Dielectric plates between the electrodes are supported below. The electrodes may be adjustably spaced by screws. The two armatures of the ozone generator are shunted by a discharger consisting of spaced metallic balls. A strong current of air or steam is preferably injected between the balls. An auxiliary ozonizer may be interposed in shunt between the discharger and the main ozonizer, working only during the passage of the spark in the discharger. The power of this auxiliary generator may be increased by a small auxiliary transformer.